Evaluation of CMHC-2 Volume 1

Submitted to:
Wayne Webster
Research Division
Canada Mortgage and Housing Corporation
Montreal Road
Ottawa, Ontario
K1A OP7

Prepared by:
Michael Sulatisky
Energy Conservation Program
Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan
S7N OX1

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DISCLAIMER

This study was conducted by Saskatchewan Research Council for Canada Mortgage and Housing Corporation under Part V of the National Housing Act. The analysis, interpretations, and recommendations are those of the consultants and do not necessarily reflect the views of Canada Mortgage and Housing Corporation or those divisions of the Corporation that assisted in the study and its publication.

ABSTRACT

The Saskatchewan Research Council review of CMHC2 focused on how it might be used in and by the housing industry, the reactions of specific representatives of the industry, comparisons with other available programs, refinements and improvements recommended to the prototype version, and considerations affecting the sale and distribution of the product. The various groups identified were Private Businesses, Government Agencies, Educators and Researchers, and the R2000 Coordinators. Recently sales of computer programs for evaluating the performance of housing in North America has clearly demonstrated the need for such a product. A survey of the representatives from all sectors of the low-rise residential industry indicated approximately 50% would purchase CMHC2. Most of the 30% who were undecided did not have the authority to make the decision. Builders comprise the largest user group, followed by architectural and engineering firms, educational institutions, building product manufacturers, and finally, government agencies and utilities. Limitations were noted in the areas of program documentation and instruction manuals, the base data (climatic and cost-performance) provided, the difficulty in accessing data, the lack of recommendations for existing structures (retrofits), and the limited amount of validation available. It was stated that "CMHC2 is one of the most sophisticated computer programs developed for low-rise housing." and the survey participants, each recognized one or more applications with which they had a primary interest. CMHC2 was seen as compatible with public sector initiatives undertaken in the future, and further, could be a useful tool to enhance their implementation. The report concludes that there is a need for a program like CMHC2, it is unique, it requires further refinements and additional features prior to release. It was recommended that a private company be made responsible for promotion and distribution.

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EXECUTIVE SUMMARY

An evaluation was made of the CMHC-2 computer program. The broad objective of the study was to investigate the factors that will influence the widespread application of CMHC-2. These include:

- the need and user requirements,
- comparisons with other competing programs, and
- proposing a final development package for the program.

The investigation was divided into three parts: a user investigation, a comparative study based on 4 other programs, and the development of an implementation strategy. Demonstrations were made to 16 potential users from the building industry in Saskatchewan, and 4 from Manitoba and Alberta. The participants included: 4 builders, 3 representatives from EMR, 4 consultants (architects, engineers, and house designers), 2 educators (University and Technical School), 2 researchers, a manufacturer, the President of the Real Estate Board, and representatives of the local utility, the Provincial Housing Department and the Provincial Agriculture Department. For the purposes of analysis the participants were divided into 4 groups:

- Private Businesses,
- Government Agencies,
- Educators and Researchers, and
- R2000 Coordinators.

A major portion of the comparative study was subcontracted to the consulting firm of G.K. Yuill and Associates. Work on the implementation strategy combined the resources of SRC's Energy Program staff and Industrial Engineering staff.

A need exists for computer programs to assess the thermal performance of both new and existing housing across North America. The best evidence of this is the number of sales of the HOTCAN program over the past two years. Approximately 850 copies of the program have been sold: 40% of the sales are to the United States. According to the firm given the marketing rights to the program, they are only starting to advertise in the U.S. market.

Moreover, there appears to be a market for programs like CMHC-2 that assess both thermal performance and cost effectiveness. About 50% of the participants in the user investigation indicated they were prepared to purchase CMHC-2. An additional 30% were undecided, but this may have been because they did not have the authority to make the decision.

The user interviews indicated that the participants were mainly interested in operating the program in the following modes:

- MODE 1 (simple analysis),
- MODE 2 (user specifies the cost), and
- MODE 5 (energy auditing and retrofit).

The users expected to run about twice as many cases in MODES 1 and 2 as in MODE 4, the optimum upgrade routine. Furthermore, they showed the least amount of interest in MODE 3 (program specifies the cost). This is because they were adamant about using their own costs for financial analysis. A number of users were prepared to enter their own costs into the Data Management System and run the optimization routine in MODE 4. This is the only way the optimization feature was thought to provide useful results.

The comparative study indicated that there are 22 computer programs available for assessing the thermal and financial performance of buildings in North America. However, only 4 were seen to be comparable to CMHC-2:

- CALPAS-3 ($795 U.S.),
- CIRA ($300 U.S.),
- F-LOAD ($425 U.S.), and
- HOTCAN ($55 CDN).

The remaining programs were found to be out of date, or designed for sophisticated users, or over-simplified.

CALPAS-3 and F-LOAD are aimed at both residential and small commercial buildings, while one of CIRA's main applications is in energy auditing and retrofits. CIRA contains an optimization package that ranks the various energy conservation measures that can be incorporated into a retrofit, similar to that proposed for MODE 5.

Many of the features contained in the above programs are similar to those contained in CMHC-2, and many features are different. Please refer to Section 5.0 and the accompanying report by the consultant for details.

CMHC-2 also has an application in delivering performance standards and energy labelling to the building industry. Interviews with four builders in Manitoba and Saskatchewan indicate that they favour a performance standard over a prescriptive standard. Furthermore, they are in favour of energy labelling of houses. Their only concern is that it will add to the cost of the houses. An airtightness test will be required to ensure that the performance standard is met, and confirm the label. This is in addition to the costs associated with running the

computer program. However, one builder plans to set up a computer in a show home and demonstrate to perspective buyers how they arrived at the advertised energy use. He feels that energy labelling is a coming requirement.

The user investigation indicated that the operation of the program could be significantly improved if a number of features are improved. These are:

- The method for determining the proper code for a construction assembly or heating system should be revised and simplified so that the user does not have to enter the tables to find the proper code.
- The "cryptic descriptors" should be replaced by proper wording to describe the building assembly or heating system.
- The recommendations for upgrades should be made consistent throughout the house.
- Attempts should be made to make the program more user friendly. Many of the participants found a number of program features complex, confusing and cumbersome.
- The errors and anomalies in the Data Management System must be corrected.

The participants in this study suggested that future technical development of the program concentrate on:

- recommendations for retrofits in MODE 5.
- incorporating climatic data for 54 cities. (Provision should be made for cities in the United States as well.), and
- the provision to enter the results of an airtightness test into the program.

Based on the user interviews, overall development of the program should be directed at:

- finalizing the user manual,
- improving the ease of access to the Data Management System,
- studies to validate the program, and
- documenting the theoretical basis for the thermal and financial analysis packages.

The marketing and implementation strategy concentrated on defining the product, determining the price for the product, and estimating the size of the market. The product includes the discs, the manual, the training program, and a list of items that back up the program.

CMHC should consider making two products available:

- a simpler version of CMHC-2 consisting of MODES 1 and 2. (The user investigation showed a decided preference by users for these modes of operation.), and
- Super CMHC-2, the current program under development.

CMHC-2, consisting of a thermal and financial analysis package, could then break the ice for Super CMHC-2. And when performance standards and energy labelling are put in place, Super CMHC-2 could fill this need, as well as the need to handle optimization, Medium Energy-Efficient Housing, and retrofit.

CMHC must also decide on how to market the program. Based on the user interviews, 14/20 participants are in favor of training courses. They feel they may require a training course to learn how to operate the program.

The participants in the study were asked to estimate a fair price for the program. The results indicate an average price of about $235

a copy, with most of the responses ranging from $200 to $300. Note that this is more than a factor of 2 less than the cost of the U.S. programs, but substantially more than the cost of HOTCAN. If the market for the U.S. programs is declining, then CMHC-2 cannot be sold for more than $100. It is recommended that an investigation of the number of sales for the U.S. programs be undertaken in the immediate future.

The size of the market for programs like CMHC-2 is estimated to range from about 1500 to 3700 copies in Canada. Because of the limited nature of this study, these figures could be in error by a factor of 2 or more. The estimate is based on data from Statistics Canada and on the number of memberships in the Canadian Home Builders Association.

If the above results are combined with an average fair price of $235, total sales in Canada will range from about $350,000 to $870,000. Since 40% of HOTCAN sales are to the U.S. market, and the U.S. market is a factor of 10 larger than the Canadian market, possible sales range from $3,500,000 to $8,700,000. Based on this, CMHC should consider incorporating an air conditioning routine into the program.*

Marketing the program should be undertaken both through the public sector and by the private sector. The R2000 coordinators stated that they would require a strong reason to switch from HOTCAN to CMHC-2. EMR is currently committed to HOTCAN in both the R2000 program and in ENERSAVE. Moreover, they are pursuing the development of a retrofit package for HOTCAN called HOMEPLAN.

Other public sector initiatives can and probably will be undertaken in the future. For example, CMHC-2 could be tied to a 0.5% reduction in the mortgage rates for energy-efficient housing in Canada. This

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* Climate data for U.S. cities should be incorporated as well.

would be a stimulus to a stagnant housing industry and would be simple to administer if it were tied to a performance standard. This can be justified by the impact on energy conservation and job creation. Moreover, CMHC-2 could be tied to retrofit and rehabilitation projects across Canada.

At the same time, CMHC-2 should be distributed by the private sector, either through the mail or through training courses. But it will be difficult for the company to make a profit if the price of the program is less than $100. A subsidy would probably be required. If HOTCAN is viewed by the marketplace as a major competitor of CMHC-2, then the program cannot be sold for more than $55. This would basically cover the cost of the discs plus the manual with no room for salaries or profit. A thriving business cannot be based on a price of $100 and a potential market of 1500 to 3700 copies. The only alternative is to persuade HOTCAN prices to go up.

1.0 INTRODUCTION

The Research Division of Canada Mortgage and Housing (CMHC) is in the process of developing a computer program for both energy and financial analysis of low-rise housing. The program, which is called Computer Model for Heating Cost-effectively (CMHC-2), was developed because of CMHC's concerns regarding:

- the affordability of energy conservation measures,
- overall cost-effectiveness,
- where the money can best be spent (mortgage or conservation measures), and
- how much should be spent.

The intent was to develop a computer program that would assist builders, designers, policy makers, researchers, and educators in evaluating energy conservation measures using state-of-the-art techniques.

CMHC-2 contains three main components:

- a heat transfer and energy analysis program which calculates the space-heating requirements of houses, given the thermal resistance and airtightness of the building envelope, and using algorithms for heat gains from electrical appliances, solar energy, and the occupants;
- a financial analysis package that calculates the monthly and annual energy bills and investment parameters for an upgrade (payback period, net present value, rate of return, etc.); and
- data files that contain performance (R-value, efficiency) and cost data for about 1600 building assemblies and heating and ventilating appliances.

The program is presently at the final development stage. All features of the program have been debugged to the point where CMHC-2 is producing reasonable results, with only a few exceptions. For example, the costs in the data files are at least a year out of date. Moreover, the data files contain a number of anomalies that must be rectified before the program is released for general use. It should be noted that the primary effort up to this time was placed on getting the program running. Anomalies in the data files were to be dealt with at a later date.

The purpose of this project is to evaluate the effectiveness of CMHC-2 in meeting the needs of a variety of users who have an interest in improving the thermal performance of both new and existing housing. There is a need to know:

- the performance of CMHC-2 relative to other publically available programs,
- the present and future needs of users,
- if the application options of CMHC-2 are reasonable, and
- the final development course for the program.

The study is divided into three distinct components. The first part is an investigation directed at users and applications. The second part compares CMHC-2 with other competing programs. This is followed by an analysis of the procedures and factors involved in implementing the program covering technical changes, promotional techniques and future development work.

The approach taken for the user investigation is statistically narrow, but contains considerable factual depth. A sample of 20 potential

users was selected, covering all potential user categories of the low-rise residential industry in Saskatchewan. The user sample was divided into 4 groups and the program was demonstrated to each group in a half-day session. At the end of the demonstration each participant was asked to fill in a questionnaire that elicited their views on the need for the program, the usefulness of the application options, and their views on the future development of the program.

An interface study was to be conducted to gauge the response of other agencies, across Canada, to CMHC-2. Moreover, six builders were to be interviewed to determine their attitudes on the relative advantages of performance versus perscriptive standards and energy labelling of houses.

The consulting firm of G.K. Yuill and Associates was subcontracted to compare CMHC-2 with other programs that serve the building industry. This consisted of an identification of available programs, a detailed review of 4 programs, and comparisons with CMHC-2. A preliminary report and a draft final report were received in February and April, 1984 (1,2).

The future developmental course for CMHC-2 was based on the results of both the above investigations. This was followed by the preparation of a marketing and implementation strategy, designed to optimize user acceptance of the program.

The results contained in this report are based on the views of 20 potential users and a comparison with 4 competing programs: 3 from the United States and 1 from Canada. Both the interface study and the interviews with 6 builders have been completed. These results have an important impact on the marketing and implementation strategy.

The objectives of the study are provided in the next section. This is followed by the procedures used to conduct the user investigation, comparative study, and implementation analysis (Section 3.0). The results from the user investigation are presented in Section 4.0 and in the appendix. Here the results from the questionnaires have been compiled under four separate headings: private businesses, government agencies, researchers and educators, and R2000 coordinators. The questionnaires, filled in by each participants, will be bound into a second volume and be kept confidential. Note that a number of participants made this a requirement of their participation. Volume II will only be made available to the staff of the CMHC Research Division and the SRC Energy Program Staff.

A summary of the results of the comparative study and an assessment of CMHC-2 are given in Section 5.0, and 6.0, respectively. Section 7.0 is devoted to assessing the need, present and future users, and facilitating and constraining factors in a general sense. The final development package for CMHC-2 is given in Section 8.0. This is followed by an implementation strategy in Section 9.0, and a discussion of the results in Section 10.0.

2.0 OBJECTIVES

The objectives of this study were:

- To review the need and user requirements for energy analysis programs such as CMHC-2,
- To identify other computer programs similar to CMHC-2 and determine their advantages and limitations in comparison to CMHC-2,
- To confirm the application options for CMHC-2, and
- To define a final development package required to bring the program to the application stage.

3.0 EVALUATION PROCEDURE

3.1 User Investigation

This was divided into the following components:

- familiarization with CMHC-2,
- selection of user sample,
- design of questionnaire for users,
- demonstration of CMHC-2 to potential users, together with application of the questionnaire,
- collation and analysis of results, and
- interviews with 6 builders on performance versus prescriptive standards and energy labelling.

The method used to conduct the investigation is provided below.

A member of the Project Team was charged with becoming totally familiar with CMHC-2. This was done to make the demonstrations of the program run smoothly. It involved setting-up the program, learning how to run it, and establishing one or more test cases for demonstration purposes.

The user sample was selected to cover all potential user categories in Saskatchewan. This allowed for a relatively wide investigation at a relatively low cost. Moreover, the building industry and its related infrastructure in the Province has several years experience in energy-efficient house construction. This experience was believed to be of considerable value in meeting the aims of the project.

The user sample consisted of:

- a builder active in establishing residential standards,
- a builder active in the Canadian Home Builders Association,

- a layman who constructed his own energy-efficient house,
- the President of the Saskatoon Real Estate Board,
- a representative of the local Architect's Association,
- a Professor of Mechanical Engineering with research experience in energy conservation and solar energy,
- a representative of the Saskatchewan Housing Corporation (policy level),
- an insulating siding manufacturer,
- an engineer concerned with farm energy use from Saskatchewan Agriculture,
- an engineering consultant,
- a representative of Saskatchewan Power Corporation (Customer Relations Department),
- a representative of Saskatchewan Energy and Mines,
- representatives of Energy, Mines, and Resources Canada (CREO office),
- a representative of a technical school (building trades),
- a representative of the National Research Council (DBR), and
- a representative of a consulting firm working in the area of energy conservation in housing.

Although the above sample was statistically narrow, it provided a cross-section of individuals that was strongly representative of all sectors of the low-rise residential industry. Hence, the sample contained a considerable amount of factual depth.

CMHC-2 was demonstrated to the 16 users in a series of half-day sessions, with about 5 sample members at each. The demonstration was

based on showing them how the program works and what it is capable of doing. They were introduced to the program by a 15 minute audio-visual presentation, developed by CMHC. Then a more detailed presentation was made using an overhead projector. This was followed by demonstration runs at the computer. However, before each major feature was demonstrated at the computer, the overall intent was described to the users with the assistance of visual aids. This was followed by a presentation of the results of the demonstration using the overhead projector. Note that about equal time was spent lecturing using visual aids, and at the computer, in order to give the potential users a fair understanding of the program, and a feeling for the different ways it can be operated.

Following the demonstration, each member was asked to fill in a questionnaire. The questionnaire was designed to elicit the information required for the report. A copy of the questionnaire is provided in the appendix. The main opinions identified were:

- the need for the program in their area of work,
- the usefulness of the applications of CMHC-2, and
- general and specific concerns about the program and its future development.

Related questions were also asked regarding:

- the features they like or dislike,
- the preferred method of access, and
- other programs they are presently using.

Once the questionnaires were completed, an informal "discussion" was held to record any important comments that the users cared to make.

Six leading-edge builders were interviewed as a separate task in order to determine their attitudes on the relative advantages and disadvantages of performance versus prescriptive standards. This was done because the sample described in this section did not contain enough builders to give a representative cross-section of opinions.

The questionnaires were grouped into the following categories: private businesses, government agencies, educators and researchers, and R2000 coordinators. Because of the small sample size, statistical techniques could not be used to analyze the results of the questionnaires. The pertinent results for each category were hence reduced from the questionnaires.

3.2 Comparative Study

This was divided into four components:

- the submission of a preliminary report that listed all the programs used in North America for energy analysis in low-rise housing (1),
- a detailed review of programs that are similar to CMHC-2,
- a review of users of the selected programs, and
- the submission of a final report (2).

The consulting firm of G.K. Yuill and Associates was subcontracted to conduct a major portion of this work.

The purpose of the preliminary report was to inform SRC and CMHC on the various existing programs, so that an early decision could be made on which programs to include in the detailed study. The detailed program review was to include a short description of each program, and the relative advantages and limitations of each program compared to CMHC-2. Although this evaluation did not require the subcontractor to

run each of the programs selected, he had experience running one program (HOTCAN), and obtained a second (F-LOAD) for the study.

A small sample of users was contacted to elicit the following information regarding the application of each of the selected programs:

- the factors that induced them to select the program,
- the degree of satisfaction with programs,
- suggested improvements in the programs,

Moreover, and where possible, the subcontractor was to approach the authors of the programs to determine the problems they have experienced in marketing the program.

The subcontractors final report was to address the following:

- regarding the programs selected for comparison: the ease of input, appropriateness of output, analysis method, documentation, cost, maintenance, and updating requirements,
- evaluate CMHC-2 compared to the selected programs,
- summarize the useful elements of the programs that could be incorporated into CMHC-2,
- specify the requirements for an ideal program, and
- comment on marketing and program access factors that should be drawn to CMHC's attention.

3.3 Implementation Analysis

This consisted of the following components:

- a review of the accumulated information (questionnaires, subcontractor's report),
- preparation of a marketing and implementation strategy, and

- evaluating the interface of CMHC-2 with other public sector energy conservation initiatives.

The marketing and implementation strategy was based on:

- size of the market in the various user categores,
- where to target the major marketing thrust,
- how to get users of existing programs to switch to CMHC-2,
- what changes to the program would increase its penetration of the market, and
- the need for the program in the various user categories.

In addition, the requirements for field trails were determined, along with the suitability to support other public sector initiatives such as standards, and energy labelling.

Over the past few years, the public sector has been an important driving force behind the implementation of energy conservation practices in Canada. In order to gauge the response of other agencies across Canada to CMHC-2, and see how it could fit into their activities, agencies across Canada were to be contacted for their views. After consultations with CMHC, this approach was abandoned in favour of another, more definitive approach. It happened that EMR was meeting with CHBA on the R2000 program in Saskatoon during the course of this study. Representatives from all regions of Canada (R2000 coordinators) were attending seminars on delivering the R2000 program. It was decided to demonstrate CMHC-2 to 4 members of this group and have them fill in the questionnaire. This would tend to give the results a National perspective that was previously lacking.

4.0 RESULTS FROM USER INVESTIGATION

4.1 Introduction

CMHC-2 was demonstrated to 20 potential users in 4 separate sessions. This section summarizes the results from both the questionnaires and the general discussion that took place at the end of each demonstration. The results were sorted into four main groups of possible users:

- Private Businesses,
- Government Agencies,
- Researchers and Educators, and
- R2000 coordinators.

A copy of the questionnaire is provided in Appendix A for reference purposes. A total of 30 questions were asked. To check for consistency in the results, more than one question addresses the same subject. The responses of the above businesses and agencies are compiled under 17 different headings in Appendices B, C, D, and E.

The results of the user investigation are compiled in the sections that follow under the headings:

- existing programs and computers being used,
- usefulness of CMHC-2,
- benefits, needs met, and features liked,
- needs not met, features not liked and to be improved, and
- applications of CMHC-2.

Results pertaining to future development of the program and the fair price to pay for the program are given in Sections 8.0 and 9.0, respectively.

4.2 Private Businesses

This group contained two builders, an architect, the President of the local real estate board, an owner-builder, and a building product manufacturer. The overall response of the group to a number of questions follows. Refer to Appendix B for more detailed responses.

Programs and computers:

Four of the six participants run from 10 to 15 cases per year on the HOTCAN program. In general, they find HOTCAN adequate for their present needs, although they would like a feature incorporated that would allow them to save data files. As well, they would like improvements to be made in the cost of energy calculation.

All the participants have access to computers. Types include: Wang, IBM-PC, TRS-80, IBM-System 32, and HP3000 series. The computers are mainly used by accounting personnel, draftsmen, or real estate sales personnel for listings. Access to CMHC-2 is preferred on their own computers and not from a central agency (like CMHC). Three of five users expect CMHC-2 to run on their present machines.

Usefulness of CMHC-2:

In terms of the usefulness of the application options of CMHC-2, the participants felt that MODES 1 (simple analysis), 2 (user specifies cost), and 4 (optimum options) were about equally useful. However, they believed they would run about twice as many cases in MODE 1 than in MODES 2 or 4.

MODE 3 (program specifics costs) was thought to be the least useful, mainly because they were adamant about using their own costs for financial analysis. This would be accomplished by either using the overall cost of an upgrade, or entering the cost of each component in the data files.

Benefits, needs met, and features liked:

All participants agreed that CMHC-2 was a sound basis for including energy conservation features in a house, although they did not feel it would result in increased profits for their companies, or improved housing sales. The needs of each user were different, but there was a common thread in their responses. They felt that the program offered the same type of thermal analysis as HOTCAN, with the additional feature of a comprehensive financial analysis package. Moreover, CMHC-2, was seen to provide the user with the priorities, the costs, and the energy savings for a large number of upgrades. All of these features meet their needs.

A number of the users liked all the features of the program. Of the available features, they identified the following two as beneficial:

- the ability to do multiple comparisons including payback period and results over the term of the mortgage,
- the potential in the program for graphical output (pie charts, bar charts).

Needs not met, features not liked and to be improved:

CMHC-2 more than meets the needs of the average user in private business category; however, there are a number of problem areas. According to the President of the real estate board, there is no application for this program, or any other program of this type, in real estate sales. The reason for this is the largest real estate market is in existing houses. Moreover, sales personnel do not have the basic skills to run even a user-friendly program.

Only two of the six participants thought they would not use the program. The following reasons were given:

- more refinement needed (get the bugs out),
- the data base in not accurate (costs),
- it would be difficult to train people for the amount of time it would be used.

Virtually all the potential uses found some faults with the program. The main features not liked and to be improved are the coding system and the data base. The method used for selecting codes for building materials and heating systems was thought to be confusing and not very specific. Moreover, the program was viewed as being slow, with a lot of time and work required to get the necessary results.

Applications:

The participants agreed that the most important applications of the program were in new construction and in the retrofit market. Both the costing features in the program and the ability to conduct an analysis of custom designs were also given high marks.

4.3 Government Agencies

This category contained representatives from Energy, Mines and Resources Canada, Saskatchewan Agriculture, Saskatchewan Housing, and Saskatchewan Power Corporation. The comments that follow are based on data given in Appendix C.

Programs and computers:

Each of the agencies have the HOTCAN program available for general use; however, many of the participants have not put it to use because the program was only recently received. (This indicates that the market

is continuing to develop). The local EMR office runs about 200 to 300 HOTCAN cases per year. All users appeared to be happy with the program.

The group prefers to access programs like CMHC-2 on their own Personal Computers. Two of five participants have an IBM-PC/XT in house, in addition to a wide variety of other computational facilities.

Usefulness of CMHC-2:

The most useful option to this group is the energy audit and retrofit feature (MODE 5). The simple analysis mode (1) and the optimum options mode (4) were also thought to be very useful, although the frequency of use is estimated to be a factor of 2 lower than MODE 5.

They identified the incorporation of a data base for retrofit as being critical for its use. However, similar to private business, they prefer to use their own costs for any calculations. They also feel that the ability to incorporate their own performance parameters and default values into the program are important. The average user in this category will probably run about 160 cases a year.

Benefits, needs met, and features likes:

The main benefits of CMHC-2 to this group are:

- a sound basis for including energy conservation features in a house, and
- a firm basis for designing energy conservation programs and policies.

They felt that the program will probably more than meet their needs, if the retrofit part of the program is developed. Moreover, they liked the financial package and the wide variety of other program features. These include: the ability to make comparisons of upgrades, and reconciliation with fuel bills.

Needs not met, features not liked and to be improved:

Although it was too early to tell by some participants, simplicity, speed, and quick calculations are needs not met by CMHC-2. Three of the five participants said they would not use the program. The following reasons were given:

- extemely lengthy input/output routines (time), and
- the program may be more precise than required.

In addition, they saw problems in maintaining the data base. This is reflected by the large number of codes which appear to be cumbersome and the number of errors in the data base. Aside from a few cosmetic changes, the main feature that needs improvement is easier access to the data files (codes and a user-friendly Data Management System).

Applications:

Their main application for the program is for existing construction retrofits and financial analysis.

4.4 Researchers and Educators

This category contained representatives from a research consulting firm, a technical school, NRC, and SRC. The following comments and responses to questions are based on the data in Appendix D.

Programs and computers:

Four of the five participants use the HOTCAN program. The representative from the university also has access to DOE-2 and ENERPASS. Similar programs are not available at the technical school. Their assessment of HOTCAN ranged from adequate to excellent. The only problem identified was over predictions.

A wide variety of computers are available to each of the participants, although 3 of 5 users would have to purchase an IBM-PC to run CMHC-2. All prefer to access CMHC-2 on their own Personal Computer.

Usefulness of CMHC-2:

Except for the simple analysis mode of operation (MODE 1), this group felt that the remaining modes of operation (2, 3, 4, and 5) had little application in their area of work. They thought the main application of the program would be in the construction industry (builders).

Benefits, Needs met, and features liked:

The main benefits of the program to this group were identified as improved research, development and demonstration capabilities. Improved teaching capabilities were also seen to be important. In terms of their own needs, they thought they would use the program mainly for research purposes: performance, cost, and comparison with other models.

On the whole, they were very impressed with the broad range of features in the program. These were identified as follows:

- menu-driven, user friendly, well-designed screens, ease of branching to different parts of the program,
- appears to be a lot of good sound technology behind it,
- the upgrade ranking feature in MODE 4 was thought to be very clever (fantastic), and
- the financial package.

Needs not met, features not liked and to be improved:

This group leveled the greatest amount of criticism on the program. Their main complaints were:

- it is a complex program that contains a number of defects and bugs,
- the assumptions and algorithms in the program have not been documented and subjected to a public review, and
- the program has not been verified.

Because of the above, they have a distrust of the program and a lack of confidence in the data files. A long list of features that are not liked and should be improved are given in Appendix D.

Applications:

The potential users in this group gave the following as the major applications of the program in their area of work:

- research, development, and demonstrating
- new house construction, and
- retrofits for existing housing.

4.5 R2000 Coordinators

Of the public sector initiatives in energy conservation, the R2000 home program is one of the most visible. It combines the resources of the Canadian Home Builders Association with those of Energy, Mines and Resources to deliver super energy-efficient housing across Canada. Four R2000 coordinators from Manitoba and Alberta were asked to participate in this evaluation to:

- give the results a more National perspective, and
- discover how the program can best fit into their activities.

The participants consisted of a builder, a consulting engineer, a house designer, and a representative of EMR.

Programs and computers:

The participants use the HOTCAN program on a day-to-day basis. They are happy with the program and rated it as fair to excellent. All users have access to computers. Types include IBM PC/XT, North Star Advantage, and mainframes.

Usefulness of CMHC-2:

The potential users gave MODES 1 (simple analysis) and 2 (user specifies cost) as being the most useful. Like virtually all other participants in this study, they were adamant about using their own costs in the program. They appeared to be the least interested in energy auditing and retrofits and indicated they would run CMHC-2 between 0 and 50 times per year.

Benefits, needs met, and features liked:

Improved teaching capability in regards to the cost and performance of energy conservation technologies was viewed as the primary benefit of CMHC-2 to this group. As R2000 coordinators, part of their activities involve instructing builders on super energy-efficient housing.

Cost-benefit analysis appears to be the most important need met by CMHC-2. They liked the fact that it provides a more detailed financial analysis than HOTCAN. The ranking of upgrades based on financial considerations was seen to be beneficial because it would help justify to clients the various choices for upgrades. They also liked the infiltration model and the data bank of RSI values.

Needs not met, features not liked and to be improved:

The group felt they would require strong reasons before switching from HOTCAN to CMHC-2. For example, the program would have to be verified and shown to be more accurate than HOTCAN. Moreover, the group viewed the program as having the following major deficiencies:

- appears to be a bit tedious to use, specifically the coding system, cryptic descriptors, and library of building assemblies,
- lack of detail regarding algorithms used for thermal and financial analysis, and

- difficulty in keeping the files in the Data Management System up to date.

In general, the group felt that the user-friendly features of the program would have to be improved before it would be used extensively.

Applications:

The primary applications of the program were seen to be in the areas of new construction and existing construction retrofits. Research, development, and demonstration were also seen to be important applications of the program. Note that 3 of 4 individuals in this group also run private businesses in the energy conservation area.

4.6 Performance/Prescriptive Standards and Energy Labelling

Four builders from Saskatoon and Winnipeg were interviewed to determine attitudes on performance versus perscriptive standards and energy labelling of houses. CSA is currently developing a standard that would allow for a label to be placed on a house that would indicate the average energy use. Performance standards are thought to allow for greater flexibility on the part of the designer or builder in house design and construction. These changes in the building industry could be brought about more easily and effectively with the aid of a program like CMHC-2. Furthermore, MODE 4 in CMHC-2 was designed with the above considerations in mind.

The questions asked and comments of the builders follow:

What do you see as the advantages or disadvantages of a performance versus a prescriptive standard in energy conservation?

Builder 1: This builder sees no problem with a performance standard. However, a prescriptive standard is easier to build to and

to enforce. To ensure that a performance standard is met, air tightness tests would be required. This would add to costs, which would have to be passed on to the customer.

Builder 2: This builder could not say if he preferred a performance standard to a prescriptive standard. He would be prepared to build to either standard, depending on what his customer wanted.

Builder 3: A performance standard is favoured by this builder because it allows for greater flexibility in design and construction.

Builder 4: A performance standard is favoured but an airtightness test would be required as a minimum to ensure that houses conform to the standard. This would add to the cost of the building.

Are you in favour of or opposed to energy labelling of houses?

Builder 1: No problems are seen by this builder, but a performance standard and an airtightness test would be required to guarantee the label.

Builder 2: An energy label sounds like an excellent idea to this builder.

Builder 3: The company perceives energy labelling of houses as a coming requirement.

Builder 4: A labelling system could logically follow a performance standard, but this would result in increased costs.

Would you like to see the performance of a house established theoretically using a program like HOTCAN, or CMHC-2, or by measurements with door fans and monitoring equipment?

Builder 1: This builder considers a computer program to be a good tool for determining house energy performance.

Builder 2: They would like to see the design based on measurement.

Builder 3: This builder plans to set up a computer in a show home to demonstrate to perspective buyers how they arrived at the advertised energy use and savings.

Builder 4: They see a computer program as the most logical means of designing to a performance standard.

5.0 RESULTS FROM COMPARATIVE STUDY

5.1 Introduction

The consulting firm of G.K. Yuill and Associates were subcontracted to evaluate existing computer programs available in the market place in in Canada and the United States. Of the 22 programs available for use, only 4 were seen to be comparable to CMHC-2: (sales price in brackets):

CALPAS-3	-	Berkeley Solar Group ($795 U.S.)
CIRA	-	Lawrence Berkeley Laboratory ($300 U.S.)
F-LOAD	-	Solar Research Laboratory, ($425 U.S.) University of Wisconsin
HOTCAN	-	Division of Building Research ($55 CDN) National Research Council of Canada

The remainder were found to be out of date, or designed for technically sophisticated users, or over-simplified. Still others were designed for limited applications at specific locations.

The following 7 sections were abstracted from the consultant's report (2). The final section is devoted to defining the performance criteria for an ideal program.

5.2 Program Availability

Program availability is an important consideration in the marketing of this type of program for widespread use. Programs may be purchased, leased or run on a timesharing basis. Users with in-house computer facilities would, of course, want to obtain the program source code and documentation. However, it is unlikely that all prospective users would have the same computer systems. Therefore, in order to better market a program, it should be available for use on a wide variety of equipment, and the user should have confidence that the program will be the same no matter which equipment it is run on.

The authors of the CALPAS-3, F-LOAD and CIRA programs have addressed this issue. All three of these programs are available for use on a variety of computer systems. The HOTCAN program has been written for use on a very limited number of machines. In fact, the only versions the authors have complete confidence in at this point are the versions available for use on an Apple Microcomputer (HOTCAN is being used for the R2000 Program and it is planned to use it for a nation-wide energy auditing program).* CMHC should give this point careful consideration when they prepare to market the CMHC-2 program.

5.3 Program Maintenance

Program maintenance, whether the program is leased or purchased, plays an important role in the selection of a program. Programs which are widely used are generally maintained by the author. Both the CALPAS-3 and F-LOAD programs have some form of maintenance programs. Programs which are developed for research purposes are usually only available on an "as-is" basis. These programs often have "bugs" or limitations that have not yet been identified, and the user must risk using the program. One of the HOTCAN program's main shortcomings is that it was originally developed as a research program for in-house use. HOTCAN has not really been distributed in a manner which would allow for maintenance follow-up. Copies of the program disks have been casually exchanged so many times that it would be difficult to trace all of the users. CMHC should address this issue and develop a policy before marketing CMHC-2.

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*Note that in August, 1984, HOTCAN-II and III were transferred to the Ottawa firm of Anderson consultants for national and international distribution. It will be made available on both the IBM-PC and Apple II computers.

5.4 Program Documentation

It is imperative that program documentation be both thorough and clear so that the user can better understand how the author intended the program to be used, and can evaluate the program's analytical basis. The user must be aware of the built-in assumptions in order to assess the limitations of the program's predictive capabilities. The four programs evaluated in this study have attempted to provide complete documentation, and have been relatively successful. However, the CMHC-2 documentation has obviously not yet been drawn together in its final form. It will require some additions, in particular a discussion of the program output and program algorithms, before it can be considered to provide the user with all the information he will need.

5.5 Program Input

The ease with which input data is prepared can affect the selection and continued use of a program. If the input is in an obscure format, requires the wrong level of detail, or is difficult to obtain and prepare, the user will not likely continue to use the program - no matter how good the analysis and output.

The CIRA program has two types of input, one for new building designs and one for retrofit analyses. CALPAS-3, F-LOAD and HOTCAN have only one type of input, and parametric studies require running the program several times. (Although the F-LOAD input is quite flexible as to the components input and the calculations performed). CALPAS-3 input is somewhat different, because unlike the previous three programs it is not interactive.

The CMHC-2 program input is quite versatile, and changes depending on the analysis desired. CMHC-2 may be used for a variety of simulations,

ranging from a simple design load prediction to a detailed economic analysis of retrofit options. Thus, the user need only prepare the input required for his level of analysis. This will be an asset when CHMC markets the program.

5.6 Program Output

The content and format of a program's output are also factors in its selection. Many program users take program output and use it directly in their reports. They require not only that the program have specific output, but also that the output be in a logical, easy to read format. The output from all the programs evaluated was basically self-explanatory, but some additional explanation was required. This is quite reasonable. Output was in tabular and/or graphical form, with the appropriate labels. These labels were sometimes abbreviated or a little unclear, but this would not be a problem as long as the user manual explains them. The CMHC-2 output appeared to be relatively clear and easy to understand, but, as previously stated, the user manuals available at present do not explain the output at all. Some users may require some explanation.

5.7 Program Algorithms

Finally, the selection of a program is also dependent on the currentness of the algorithms. Most users want to be confident that the program they use has the highest possible level of sophistication. This generally means that the program has the best accuracy and lowest computing costs. It is reassuring to know that the program incorporates the results of the most recent research.

Improving and refining program algorithms is an on-going process for the authors of all of the programs evaluated. This is a factor which can be related to program maintenance. That is, users should be made aware of program changes and the availability of the next level of the program.

As stated previously, the CALPAS-3, CIRA and F-LOAD program authors have addressed this point and HOTCAN has the resources of NRC DBR as back-up and for future development. If CMHC-2 is to be widely distributed and used, similar supported will be required.

5.8 Criteria for an Ideal Program

The criteria for an ideal computer program for both energy and financial analysis in low-rise housing is presented in Table 5.1. The content is based on the user investigation, discussions with the sub-contractor, and the experience of SRC. The criteria has been divided into both user features and modelling features.

Table 5.1: Criteria for an Ideal Program

User Features	Modelling Features
Fast, simple and easy to use	A strong technical base
User-friendly and interactive	Verified algorithms
Help routines and entry checks	Credible authors
Excellent documentation and user manual	A complete list of program assumptions
Input forms that reflect the program format	Representative default values with a range of possible alternatives
Ability to change input quickly and easily	Verified accuracy in an overall sense
Ability to use output directly in reports	Infiltration model based on wind and thermal driving forces
A flexible printout routine	Temperature dependent R-values where necessary
Graphical output in the form of pie charts and bar charts	Algorithms that adjust the performance parameters so that the calculated energy use matches the fuel bills
Good file management capabilities	Complete and up-to-date data base
Compatibility with a wide variety of computers	
Call in service for problem solving	
Availability of new versions as the technology continues to develop	
Program drop-back into the calculator mode	

6.0 ASSESSMENT OF CMHC-2

6.1 Comparison of CMHC-2 to an Ideal Program, Including Gaps and Limitations

User Features

CMHC-2 is a fairly easy to use interactive computer program. Aside from the coding system used to select construction assemblies and heating and ventilating systems, it is also user-friendly to the daily user*.

Many of the participants in the demonstration viewed the program as not being particularly fast, mainly because of the wide variety of features available in the program. This is particularly true for Mode 4 where the calculations alone take about 20 minutes. But in many respects speed is a secondary issue to many users as long as the results are useful. Moreover, it has been only over the past few years that programs like CMHC-2 could be run on a microcomputer. Costs for these types of computers are coming down and their speed is increasing, along with the size of the memory. In a few years, the problem of computer speed should be solved as the technology continues to develop.

A number of participants in the study thought the program was rather complex. This is partly because of the number of different modes of operation, but mainly because of the coding system for construction assemblies and heating systems. Terms like confusing and cumbersome were used to describe the system of codes. This part of the program is not simple to use, nor it it particularly user-friendly, yet it is at the heart of the program. And the "cryptic descriptors" only make matters worse. One of the members suggested that the ideal would be to eliminate the need for constant reference to manuals or printed tables (as in HOTCAN). If this cannot easily be achieved, the next approach is to revamp the selection method so a user does not have to go into the

*User interviews indicate relatively infrequent use for many users. This means large time gaps between successive uses where users can lose operational skills.

tables to find the proper code. Note that in many ways having to go to tables to find the assembly code is redundant. One can simply select the R-values and tightness values instead, enter them, and calculate the differences in heating costs by hand.

Entry checks for input that is out of range are made in the program. For example, an R-value of 1000 m^2 °C/W would be rejected by the program. However, the program has also flagged a number of entries that are correct. An example is an area of a basement wall of 63.2 m^2.

The range of values for flags in the data entry system should be checked for consistency. Moreover, the program contains few, if any, HELP routines. These are often necessary to assist the infrequent user, especially in the Data Management System. Although HELP routines that meet the needs of all users may not be that easy to design, a good place to start would be a statement that references a particular section of the user manual.

The user manual, developed for CMHC-2, is not in very good shape. This is not really a cause for concern at this time because program documentation usually lags behind the development of a new program. However, before the program is released, a new user manual will have to be developed. The best course to follow may be to first review the user manuals for HOTCAN, F-LOAD, CIRA, and CALPASS, and then select the best approach.

Input forms have been developed for CMHC-2 that reflect the data input screens in the program. This is a necessary feature of programs like CMHC-2 where a large amount of input must be assembled away from

the computer. At least one potential user indicated that the input sheets were a bit lengthy. The HOTCAN input sheets have been reduced to one page as compared to eight pages for CMHC-2. Supplying the input sheets for CMHC-2 is not only costly, but may inhibit the home owner from getting involved. The ideal situation in retrofit is for the input sheet to be filled in by the home owner and sent to a central agency for processing. This need appears to be outside the scope of the CMHC-2 at this time.

The output can be used directly in reports, but improvements can still be made. For example, graphical output in the form of pie-charts and bar-charts would be useful for comparing both the percentage heat loss from various components, and the before and after energy consumption and costs. Moreover, the program does not really have a printout routine. One simply prints out what is on the screen. This can be time consuming and laborious. It is suggested that a versatile printout routine be developed. A method that could be used is to list all the input and output screens with an assigned number. One could either ask to print all screens, or select any number of screens for printout by filling in the appropriate series of numbers.

The file management system appears to be excellent. However, in regards to handling the assembly and heating system data files, HELP routines would make it easier for a user who does not go into the Data Management System on a day-to-day basis.

At the present time, CMHC-2 can only be run on one micro-computer: the IBM-PC/XT. However, a number of competitors are coming out with IBM-PC clones at a lower price. CMHC-2 should be made available on a wide variety of computers. An IBM-PC should not be a necessary piece of

hardware required to run the program. Providing access to the program on mini-computers should also be reviewed. Some potential users, particularly in the business community, preferred access on larger machines.

A call-in service for problem solving and new versions of the program should be made available to the user, as new algorithms become available. These support systems are seen to be important by many program users.

Modelling Features

The technical basis of CMHC-2 was more interesting to the researchers and educators, participating in this study, than the other groups. In a general sense, they were impressed with the obvious potential and power of the program. However, they wanted to be given more details regarding:

- the assumptions built into the program,
- program algorithms,
- the names of the authors, and
- the computational language.

At the present time very little is known about the modelling features in CMHC-2. This information will have to be assembled into a document to gain credibility with this group.

CMHC-2 is one of the most sophisticated computer programs developed for low-rise housing. The infiltration model appears to be based on wind and thermal driving forces. Moreover, it contains a feature that reconciles fuel bills with the actual energy consumption. The immediate need is to document and verify all this work. Each component model must first be verified for the Canadian climate, then CMHC-2 must be verified against precise monitored data from houses. This will secure and extend the credibility of the program.

The private businesses placed less emphasis on the technical content than on the costs in the data bases. As mentioned previously, this part of the program is not up-to-date and contains a number of anomalies that must be corrected before it can be put to good use.

6.2 Usefulness of Application Options

The application options of CMHC-2 include the various modes of operation and the Data Management System.

The private businesses viewed MODE 1 (simple analysis) and MODE 2 (user-specified upgrades and costs) as being the most useful to them. This is reflected by the higher "likely importance" and "frequency of use" values for these modes than the others. MODE 3 (user-specified upgrades and system costs) was seen to be the least useful. This was mainly because they were adamant about using their own costs, which is reflected by the high score given for incorporating their own costs into the data files.

The government agencies were more interested in the auditing and retrofit potential of the program than the other features. Like the private businesses they also preferred to incorporate their own costs into the data files. Hence, MODE 3 was thought to be the least useful.

Researchers and educators selected MODE 1 as being the most useful. The importance of the remaining application options was less than 2.5 out of 5.0, indicating that they envisioned little application for the remaining features*. This is not to say that they did not like the program. In fact, one researcher thought it was fantastic, but he also thought that it would be more useful to builders than researchers.

Surprisingly, the R-values and efficiencies available in the data

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*in their area of work.

base were viewed by the potential users with indifference. Participants in general did not state that this was a particularly powerful feature of the program (which I personally believe it is). One potential user suggested that a table of R-values would be just as useful. Perhaps the problems the users perceived with accessing the data (codes) overshadowed its usefulness. Furthermore, one user wanted to know the source of the performance parameters (CMHC acceptance numbers, ASHRAE, etc.).

7.0 ASSESSMENT OF THE GENERAL REQUIREMENTS FOR MICROCOMPUTER-BASED PROGRAMS

7.1 Need

The need for computer programs to conduct energy analysis in housing arose out of energy crisis in the mid-1970's. Since that time a number of computer programs have been developed to meet the needs of users throughout North America.

The success of the HOTCAN program in filling this need is shown in Table 7.1 by the number of sales over the past two years. The figures show that in excess of 850 copies of HOTCAN-II were sold since the program was developed. Note that before January, 1983, a number of copies were distributed, but records of sales were not kept.

Table 7.1: HOTCAN-II: Number of Sales and Distribution of Sales

	NRC,DBR	Anderson Consultants
Total Sales	250	600
Price ($)	25	55
Time frame	01-1983 to 02-1985	07-1984 to 04-1985
Distribution (%)		
- builders	15 ┐ 49	55
- others	34 ┘	-
- designers, architects and engineers	15	18
- manufacturers	18	10
- educational institutions	19	9
- governments and utilities	7	-
- percentage to USA	39	40

Since August, 1984, the firm of Anderson Consultants have been assigned the task of distributing the program. According to Anderson, sales are increasing (regardless of the current oil glut). This is reflected by the fact Anderson's sales are more than a factor of 2 higher than those of NRC over about 1/4 the time period. Note that Anderson has only recently started advertising in the U.S. market, while NRC has never advertised in the media.

The distribution of sales are also interesting: the major part of the market appears to be builders and others. The term "others" is used to classify orders that could not be placed into another category. Based on the letters accompanying each order, the bulk appear to be home owners who may be planning to build a house or undertake a major renovation. The sales being made to consultants, manufacturers, and educational institutions are also significant.

About 40% of all sales are made in the US market. This is significant because the program does not contain weather data from the U.S. Moreover, the market is 10 times the size of the Canadian market.

7.2 Present and Future Users

Presently, computer programs that conduct an energy analysis of low-rise housing are being used by builders often participating in energy-efficient housing programs, educational institutions, government agencies, homeowners, and researchers. The programs are mainly used as a theoretical basis for investigating new energy conservation alternatives, from passive and active solar heating to new furnaces and insulating materials. In fact, most computer programs for energy analysis in housing were developed by the research community for research purposes.

Governments have also found energy analysis programs to be useful in developing energy conservation programs and delivering them to the public. Two main thrusts in this area are:

- the R2000, Super Energy-Efficient Home (SEEH) program, implemented by the Canadian Home Builders Association and the Federal Government. Builders participating in the program are required to model each house with the HOTCAN computer program.
- an energy auditing program, based on HOTCAN, is being developed by EMR for use in the field by auditors. This program is aimed at retrofitting existing houses.

At the levels of home owners, builders, and house design levels, the use of computer programs for energy analysis appears to be expanding (see Table 7.1). This is seen to be the result of energy-efficient housing programs like R2000 and the penetration of microcomputers into the marketplace. Note that the specifications for energy-efficient housing may have been developed using programs like CMHC-2. Builders may also use the program to develop a line of energy-efficient houses, but it is not seen to be necessary to model each house constructed on a program like CMHC-2.

A small proportion of home owners use architects, or designers, to develop customized energy-efficient house designs. Experience has shown that such designs tend to be exotic and complicated, with energy conservation being an added selling features. It is believed that modelling many of the features of these houses may require a skilled user of the program. Although this was thought to be an important reason why energy

analysis programs are not used to a large extent in this sector, this appears to be changing.

A few custom builders are now listing computer design facilities as a part of their sales promotion. Until now, the HOTCAN program has filled this need. The home owner has often been the driving force behind the construction of a custom-built, energy-efficient house. He usually has some fixed ideas about the energy conservation features of the house, and he would work with the custom builder to refine the design options.

Technical schools are presently moving in the direction of teaching students how to use Computer Assisted Design (CAD) tools in a number of disciplines. This is mainly being done in the fields of machine design and process control, where software packages have been developed. In the areas of architectural drafting and the building trades, like Carpentry, CAD packages are at the stage of entering the market.

Looking to the future, researchers will continue to use and to develop new and better programs for energy analysis. However, their interest will be confined mainly to solving technical problems: air quality, improved efficiency, moisture problems, and developing better correlations for natural infiltration and solar gain.

From the builder's point of view, the use of computer technology for energy and financial analysis will depend on the bottom line - increased profits, and improved housing sales. If programs like CMHC-2 can be shown to provide a sound financial basis for including energy conservation features in houses, then their use will likely increase.

Their is no doubt that the use of CAD packages by architectural design and drafting personnel will increase in the future. But the main use may be for the interactive design of large and small buildings: isometric views of the building, building drawings, and structural analysis. Although energy and financial analysis may be (or may not be) secondary concerns, it is believed that a complete package would be the most useful. And the Personal Computers, available in the future, should have sufficient capacity to meet both needs.

Policy makers during the energy crisis found it necessary to push energy conservation to the forefront, as a move toward energy self-sufficiency. Assuming less government intervention in the immediate future, the use of computer programs for both energy and financial analysis of low-rise housing could decrease at the policy level. (Energy conservation will have to respond to the pull of the marketplace). Note that the new Federal Government's energy conservation policy has not yet been developed; the content of any new policies is basically guesswork.

It is interesting to note what happened in Saskatchewan after the government changed. Both the Home Energy Loan Program (HELP) and Warmup Saskatchewan Program were replaced by a new program called Enerwise, a program that is much broader in scope. It provides a $3000 loan at a lower interest rate than is available at a bank. The program applies to energy conservation features in both new and existing houses. The HELP program provided an interest free loan ($3000) for only new houses, constructed to a perscriptive specification, while Warmup Saskatchewan provided up to $1000 for existing houses. With no advertising, 2000 loans were made over the last year. If Saskatchewan's example is followed, the new Federal Government will develop new and perhaps improved programs.

7.3 Facilitating and Constraining Factors

The facilitating and constraining factors in the widespread adoption of micro-computer energy programs have been discussed throughout this part of the report. The main factors are summarized as follows:

Facilitating Factors

1. Energy prices are expected to stay at about the present level to the end of the decade, then rise as the oil glut disappears due to an increase in the economic cycle and an increase in energy use in other parts of the world.
2. The penetration of computers and CAD systems into the building industry will increase as cost of hardware decreases, computer memory increases, and software packages that are easy to use become available. The pull of the marketplace will move more and more in the direction of "hi-tech" solutions to building problems. This will be supported by training courses in technical schools and at universities.
3. Over the past ten years, improved energy efficiency has been well entrenched in the minds of the public. This will be reflected in a preference for more energy-efficient buildings (as with vehicles).
4. Increasing the productivity of Canadians will be an on-going task at the policy level. Wise energy use will continue to be an important driving force in increasing prosperity, to avoid future energy shocks and make Canada self-sufficient in energy.

Constraining Factors

1. Builders are accustomed to working with prescriptive standards when constructing a house. Moving to performance standards

would increase the need for energy analysis programs and air-tightness tests. Although all the builders interviewed in Section 4.6 favoured a performance standard, they also indicated it would increase the cost to the customer.

2. Builders and home owners may not have the basic skills to run even a user-friendly computer program. Based on the number of HOTCAN sales (Table 7.1) this is becoming less and less constraining every day.
3. The program must be shown to be accurate and the data base in the program must be trustworthy and up to date.
4. The program must be easily accessible, well documented, and have an excellent support system. It should also be available for use on a wide variety of equipment.

8.0 FINAL DEVELOPMENT PACKAGE

8.1 Improvements and Modifications

The private businesses, government agencies, and researchers gave the lowest score for application options to MODE 3. In this mode, the user specifies the upgrades and the program provides the costs. This tends to indicate at best, that the costs in the data base would only be used for reference purposes. The reasons for this are partly because of a large number of anomalies in the stated costs, but mainly because they prefer to use their own costs. The general feeling was that it would be a monumental task for CMHC to provide up-to-date, accurate costs for 54 locations, or more, across Canada.

In light of this, a practical approach would be to provide a data base for an average location in Canada (say Toronto). The location should be kept confidential; it should only to known as the CMHC-2 Data Base. This would only partly inhibit the effectiveness of MODE 4 because the relative costs between regions may be similar. Of course, before the program is released, all the "bugs" in the data base would have to be corrected so that the results agree with reality. As well, HELP routines should be provided in the Data Management System to assist those who wish to incorporate their own costs.

The next major problem with CMHC-2 is the system for selecting the proper codes for construction assemblies, or heating systems. It is fairly straightforward to obtain the primary (P), secondary (S), and and tightness (T) numbers using the charts in the manual. But obtaining the identification number (ID) is somewhat laborious because one must go into the tables. Since there are only a maximum of 12 identifier numbers

for each construction set, it would simplify matters considerably if they could be listed along with P, S, and T in the charts. This will not be as simple as it seems because the identifier 4, taken on its own, can represent 8 different levels of insulation (WALLS). However, in combination with the secondary number, a method that obviates the need to go to the tables may be possible. Note that this would be a significant improvement in the program and should be investigated further.

The "cryptic descriptors" should be replaced with complete wording, or as a first step, a legend that is complete and easy to use.

In MODE 4, CMHC-2 tends to treat the house as an assembly of non-interacting components, each of which can be modified irrespective of the others. The user must interact with the program to minimize suggested upgrades that are impractical for his circumstances. But this can be time consuming. As a first step, the program should be modified to recommend the same type of air/vapour barrier for the walls and the ceiling. Methods to ensure consistency for insulation materials in the superstructure walls and basement walls should also be investigated.

The program should be checked to ensure that the recommendations made in MODE 4 meet all the building code requirements. As an example, the program uses interior door specifications for the door to the attached garage. The building code requires a solid-core door with an automatic closing mechanism. Another suggestion was to flag all building code requirements.

Wood heating is presently being used in many regions of Canada where wood is plentiful and the cost of conventional fuels is prohibitive. CMHC-2 should provide codes and fuel costs for secondary heating systems such as wood furnaces, and hybrid heating systems.

The financial analysis package in CMHC-2 is very well developed. Users will basically use it to make decisions about where to draw the line when considering an upgrade. A number of users felt that it more than met their needs. The payback period and cash flow tables were the most useful to this group. They had little feeling for the discount rate, internal rate of return, or the net present value. An understanding of these economic terms requires a certain amount of training in economics, which many of the participants may not have had. To improve the usefulness of this part of the program, a simple but detailed explanation must be given for all the financial parameters (including assumptions) in the manual. The user must also be given an explanation of how to use them to make decisions.

Utilities often use capital cost ($/kW) and levelized life-cycle cost (¢/kWh) to compare electrical plant alternatives. These terms can also be calculated for various energy conservation measures in housing. The addition of these parameters would permit the utility to make a direct comparison between constructing a new generating station and energy conservation. Moreover, the levelized life-cycle cost can be compared to the rates charged for electricity, natural gas, or oil. Many users besides utilities would be interested in the results of these comparisons. (An example was recently given in California where the cost of new generating capacity was 7.0 ¢/kWh while the cost of energy conservation was 1.0 ¢/kWh: energy conservation was a factor of 7 less expensive and could replace two Diablo Canyon Nuclear Power Stations).

8.2 Future Development

The participants in the user investigation were asked to rate a number of enhancements to CMHC-2. The results are summarized in Table 8.1. Note that these results are the average for all the participants. They were not weighted by possible number of sales in each category. This would not have been a reasonable thing to do because the builders participating in the study, for example, may not represent the views of the average builder in Canada.

Table 8.1: Future Technical Development: Scoring system, 5 (critical) to 1 (not required).

3.7	The addition of 54 cities to the data base.
3.1	Extension to a full costing program for the base house.
3.8	Recommendations and upgrades for energy audits or retrofits.
3.7	The provision to include the results of an airtightness test to calculate infiltration.
2.4	The addition of cooling analysis (air conditioning).
3.2	The capability of modelling a poorly insulated house (using codes).
3.3	A more complete description of the recommendations for upgrades.
3.7	A simpler more direct method of determining the proper code for a construction assembly or heating system.
2.4	The inclusion of a drafting package as a part of the Computer Assisted Design package (CAD).

The first part of Table 8.1 shows that enhancements in the energy auditing and retrofit areas were viewed as being the most important. Developing a simpler more direct method of determining the proper code for a construction assembly was equally important. The addition of cooling analysis and a CAD package were the least important enhancements in the opinion of the participants.

In terms of overall program development, Table 8.2 indicates that a complete and detailed manual is a vital component of CMHC-2. Ease of user access to the data files is also very important. Note that the Data Management System, in its present form, is user-friendly. However, there are a few bugs: the program did hang-up for some reason while this feature was being demonstrated to one group. (All the discs were wiped out.)

Table 8.2: Future Development Package, 5 (critical) to 1 (not required).

4.9	A complete and detailed manual.
3.4	Training packages and courses.
3.6	Program operating speed.
4.4	Ease of user access to data files.
3.7	Documentation of the theory upon which the program is based.
4.1	Field and theoretical validation of the program.
3.5	Features that allow for a comparison with various standards

Field and theoretical validation of the program is also seen to be very important. This should be undertaken in three ways:

- comparisons with theoretical solutions that are more accurate and approach an exact solution to the equations (DOE-2, BLAST),
- verification of the component models (solar gain, natural infiltration, etc), and

- comparisons of the predictions of CMHC-2 with the energy recrods from a number of houses with well-documented thermal performance parameters.

9.0 MARKETING AND IMPLEMENTATION STRATEGY

9.1 Introduction

The broad objective of this section is to investigate the factors that will lead to the widespread application of CMHC-2 into the marketplace. The primary factors include: the product, the price of the product, and the size of the market. These subjects are addressed in Section 9.2.

Promotion and distribution are also important factors in marketing a new product. This can be accomplished in a number of ways. The two methods addressed in Sections 9.3 and 9.4 are:

- interfacing with public sector initiatives in energy conservation, and
- handing the program over to the private sector for distribution.

A successful product must deliver value to customers: the product must meet a need at the right price. This simple rule of thumb is applied throughout this section to develop a marketing strategy.

It should be noted that the results of the market investigation are not conclusive. Many of the estimates made can certainly be challenged. This is because the scope of the study is somewhat narrow in a marketing context. If CMHC plans to proceed with the development of CMHC-2, this should be done in parallel with a more detailed marketing study that would fill the gaps and limitations in this investigation.

9.2 Marketing

9.2.1 The Product

CMHC-2 was developed to respond to the need for a simple analytical tool to identify how one could maximize the energy savings for different

levels of expenditure in low-rise housing. CMHC's concern is for the overall cost effectiveness of energy conservation measures in housing. Thus CMHC-2 provides guidance on:

- where the money can best be spent, and
- how much should be spent.

The program meets the above requirements by coupling a thermal analysis package to an financial analysis routine. In MODE 4 an optimization routine is used to rank the various energy conservation alternatives given in the Data Management System.

A number features of the program must be debugged and improved before CMHC-2 is made into a saleable product. Moreover, the scope of the product also includes:

- discs,
- the manual,
- the types of computers it can run on (availability),
- program maintenance,
- the training program,
- documentation of the theory behind the program, and
- the results of validation studies.

These subjects have been discussed in Sections 5.0 and 8.0 and in other sections as well.

A number of alternatives exists in defining the final form of CMHC-2. The user investigation (Section 4.0) indicated that MODES 1 (simple analysis) and 2 (user specifies the cost) were the most useful to perspective buyers. The results summarized in Table 9.1 indicate they would run about twice at many cases in MODES 1 and 2 as in MODE 4

(optimum options).

To meet this need (a simple program that will do financial analysis) CMHC should consider making two products available: CMHC-2 and Super CMHC-2. CMHC-2 would consist of MODES 1 and 2 and would be aimed at the home computer market.

Table 9.1: Overall Usefulness of CMHC-2 Scoring System: 5 (critical) to 1 (not required).

MODE	Likely Importance	Annual Frequency of Use
1 (simple analysis)	3.6	31
2 (user specifies cost)	3.1	25
3 (program specifies cost)	2.7	22
4 (optimum options)	2.8	16
5 (auditing and retrofit)	3.0	5

If the software can be slimmed down to fit onto two discs, it would remove much of the perceived complexity in the program. Moreover, it would meet the current needs of the marketplace.

CMHC-2 could then break the ice for Super CMHC-2, the current program under development. And if performance standards and energy labelling of housing are put in place, Super CMHC-2 could meet this need, as well as the need for a program to handle optimization, Medium Energy-Efficient Housing, and retrofit.

CMHC must also make a decision on how to market the program. Two possible ways are:

- to provide discs plus a manual through the mail, or

- to provide the discs and manual with a training program.

The user interviews indicated that 14 of the 20 participants are interested in a hands-on training course (see Table 9.2). Moreover, 17 of the participants would like to be kept informed on updates to the program.

At the present time HOTCAN II is being distributed by mail. One must bear in mind that CMHC-2, in its present form, is considerably larger and more complex than HOTCAN. Hence, training courses and a maintenance program appear to be a requirement of potential users.

Table 9.2: Number Interested in Training Courses and Updates

Category	Training Courses	On-Going Updates
Private Businesses	4/6	4/6
Government Agencies	4/5	5/5
Researchers and Educators	3/5	5/5
R 2000 Co-ordinators	3/4	3/4
Total	14/20	17/20

9.2.2 Price

The user investigation asked questions regarding the fair price to pay for: the program, the training course, and on-going updates. Moreover, the participants were asked if they would purchase the program based on the fair prices stated. The results are summarized in Table 9.3.

Based on the user interviews, the fair price to pay for CMHC-2 is in the $200 to $300 range (average = $235). This is significantly less than the cost of comparable programs from the United States ($400 to

Table 9.3: Fair Prices for CMHC-2 and Response to: Will you Purchase CMHC-2?

Category	Discs and Manual ($)	Training Course ($)	On-Going Updates ($)	Will you Purchase? Yes	No	Unknown
Private Businesses	300	100 to 500	Unknown	2	3	1
Government Agencies	100 to 300	50 to 100	20 to 100	4	1	0
Researchers and Educators	300	50	Unknown	2	1	2
R 2000 Co-ordinators	100 to 500	0 to 1000	0 to 50	1	0	3
Total				9	5	6

$1,000), but substantially higher than the present cost of HOTCAN ($55). It is also important to note that about one-half of the participants stated they would purchase CMHC-2 for the fair prices stated. Approximately one-third were undecided. The negative and unknown responses to purchase are understood to be a result of the following:

- participants did not have the authority to make the decision,
- concerns about the complexity and bugs in the program, and
- no application in present area of work.

If the main reason for the unknown response is due to lack of authority, then it is possible that 70% of the participants would purchase the program, given the right marketing strategy.*

It is difficult to know if any of the programs available in North America can survive in a market where one of the competing programs is selling for $55. CMHC should check the sales of the programs being sold for $400 to $1,000 to investigate if their sales are increasing. Note that 40% of HOTCAN sales are to the U.S. market (see Section 7.1). If the market for the American programs is declining, then CMHC-2 cannot be sold for more than $100.

9.2.3 Market Size

A rather limited investigation was made to determine the size of the market for computer programs like CMHC-2 in Canada. It is accepted that the results can be challenged, and can be in error by a factor of 2 or more. The results that follow should be viewed as a best guess, based on data from Statistics Canada and discussions with representatives of the Canadian Home Builders Association (CHBA).

As shown in Table 9.4, there are currently about 4,560 members in

*Note the 5 of the 6 "unknown" responses to purchasing CMHC-2 do not have the authority to purchase.

CHBA; about 1,500 (33%) are builders. For this analysis it was assumed that the members of CHBA are actively involved in construction, are progressive, and would consider purchasing a program like CMHC-2. Note that the distribution of the memberships is a best guess from CHBA.

According to Statistics Canada there are about 30,000 companies involved in building construction in Canada. This includes general contractors engaged in the construction of houses, farm buildings, public buildings, industrial and commercial buildings, or in building alterations and repair. Note that only 3% of the companies have more than 20 employees and that about 60% of the companies (18,000) have 4 employees or less.

Table 9.4: Members of Canadian Home Builders Association (April, 1985).

Category	Number	Percent
Builders	1504	33
Suppliers	775	17
Manufacturers	1140	25
Others	1140	25
Total	4559	100

An estimate of the size of the potential market for CMHC-2 is shown in Table 9.5 for five categories. Because of the lack of firm data on the number of builders in Canada both a high and a low estimate of the number of organizations is given.

The number of architectural and engineering firms is the total number of consultants for all activities in this area (architecture = 1470, engineering = 2,236). The figures for product manufacturers are based on the number of furnace and insulation manufacturers in Canada. Educational

Table 9.5: Estimate of Size of Potential Market for CMHC-2 (high estimate in brackets).

Category	Source of Information/ Year	Number of Organizations	SRC Estimate of Percentage that will Purchase	SRC Estimate of the Number of Purchases
Builders. - low - high	CHBA/1985 (Stats. Canada, Business)	1500 (30,000)	60 (10)	900 (3000)
Architectural & Engineering Firms	Stats. Canada, Research Handbook/1985	3700	7	260
Building Product Manufacturers	Stats. Canada, Business Register, 1985	420	35	150
Education Institutions (Universities & Technical Schools)	Stats. Canada: Education Statistics	260	60	160
Government Agencies & Utilities	Stats. Canada	620	13	80
Total - low - high		6500 (35,000)	25 (10)	1550 (3650)

Institutions include Universites and Technical Schools only. Note that there are about three times as many Technical Schools (197) as Universities (66) in Canada. The following agencies are included under Government Agencies and Utilities: housing (12), agricultural (10), utilities (electrical = 430, gas = 142), research organizations (15), and EMR (13).

Based on the above figures, the high and low estimate for the number of organizations involved in building construction are 35,000, and 6,500, respectively.

A survey was made of SRC Energy Program staff to estimate the percentage of the various organizations that will purchase CMHC-2. These results are shown in Table 9.5. Note that the resulting high and low estimate of percentage that will purchase is in conflict with the results of the user interviews. About 50% of the participants indicated they would purchase CMHC-2. Moreover, the results are dominated by the number of builders, the largest potential market.

SRC's estimate of the number of CMHC-2 sales ranges from a low of about 1,500 to a high of 3,700. If these results are combined with an average fair price of $235, total sales in Canada will range from about $350,000 to $870,000. Since 40% of HOTCAN sales are to the U.S. market and the U.S. market is a factor of 10 larger than the Canadian market, possible sales range from $3,500,000 to $8,700,000. However, if CMHC-2 cannot be sold for over $100, based on HOTCAN competition, overall sales will be a factor of 2 lower than given above.

The results given in Section 7.1 indicate that about 500 copies of HOTCAN have been sold in Canada. Based on the low estimate of the size of the market (1,500) about 1/3 of the market has been penetrated by

HOTCAN. Since advertising and promotion of HOTCAN has only recently been started, this tends to indicate that the low estimate of sales may not be realistic.

9.3 Interface with the Public Sector

One of the best ways of bringing CMHC-2 onto the market is on the "coattails" of a government energy conservation program. This has certainly worked for HOTCAN. The user interviews with R2000 coordinators indicate that only one of the four coordinators would be prepared to purchase the program; the remaining coordinators were undecided. They indicated that CMHC-2 has a number of advantages over HOTCAN (more detailed, costing capabilities), but they would require stong reasons to make a change. These include:

- EMR is currently committed to HOTCAN,
- accuracy of energy analysis would have to be significantly better than HOTCAN,
- the program would have to be verified, and
- complexity and time required relative to the task would have to be shortened.

Marketing CMHC-2 through the public sector can be justified by its impact on energy conservation and perhaps job creation. If the above policies are seen by the Government to be in the public interest, then there are a number of initiatives besides R2000, CHIP*, and COSP* that can be made. These include:

- a 0.5% reduction in the mortgage rates for house construction based on a performance standard, energy labelling, and CMHC-2, and
- retrofit and rehabilitation projects across Canada.

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* Note that CHIP and COSP will be terminated in 1986.

The first step that should be taken is to get the program out in the field. CMHC-2 should be made available to a number to users free of charge, across Canada. Our understanding is that this is already being done to a certain extent. However, the emphasis should be placed on users who have a particular application in mind. Piggybacking to a number of ENERDEMO projects may be particularly useful. A financial incentive of about $3,000 could be given to the consultant conducting the work to produce a brief report on the effectiveness of CMHC-2 and outlining any problems with the program.

Separate projects should be designed to demonstrate CMHC-2 for both new housing and upgrading existing housing. Again, ENERDEMO may be an important vehicle for this demonstration. It may also be useful to approach a number of provincial housing authorities to see if CMHC-2 could be demonstrated in one of their housing projects.

9.4 Interface with the Private Sector

Like HOTCAN, CMHC-2 can be turned over to the private sector for distribution. But we are not sure if a company can make a profit based on prices in the order of $100 a copy and a market size of 1500 to 3700 copies. Computer discs alone for CMHC-2 cost about $20, and printing a manual will cost at least $10. If HOTCAN is viewed as a major competitor of CMHC-2 in the marketplace, then the only alternative is to persuade HOTCAN prices to go up.

Promotion of CMHC-2 can be done at conferences, trade shows, and in trade magazines. And distribution can be provided through the mail or through training courses.

Note that there appears to be a substantial market for computer

software in low-rise housing. Moreover, sales appear to be increasing for a number of other energy conservation products in both the United States and Canada. This is because customers are getting value for the money spent. This is CMHC-2's ultimate objective, and it may fit in rather well.

10.0 DISCUSSION OF RESULTS

The results of this study are statistically narrow, but contain a considerable amount of factual depth. Because of the limitations in this study, it would have been impossible to broaden the statistical base by conducting similar user interviews across Canada. If this was done by mail or telephone, the response would have been largely hypothetical, and the net findings would have been questionable. However, now that a factual base for the program has been established, a more extensive survey could be undertaken to develop conclusions regarding marketing CMHC-2 in Canada and the United States. This could involve studies related to the small sample size and a more detailed investigation of the size of the market.

Nine of the twenty participants in this study stated they were prepared to purchase CMHC-2 at a fair price of about $235. Six participants were undecided about making a purchase, but five of them did not have the authority to make a decision. (However, they may have some influence.) If one-half of the undecided potential users can be convinced to purchase the program, then 60% would have been prepared to make a purchase. This is where marketing skills are useful; they can identify the "buttons that must be pressed" in order to capture a reluctant user or convert a negative response into a positive one. At this point in the development of CMHC-2, further development should proceed in parallel with the market investigations.

The results of the user investigation indicated that the potential users were impressed with the overall power of the program. However, the general impression was that the errors and anomalies in the data

base must be corrected before the program is released. Moreover, attempts must be made to simplify the procedure used to select the proper code for construction assemblies and heating systems. Other important recommendations include: developing a complete and detailed manual for the program, providing HELP routines in the Data Management System, and documenting and verifying both the heat transfer and financial analysis packages in the program.

The comparative study showed that there are four programs comparable to CMHC-2 on the market: CALPAS-3, CIRA, F-LOAD, and HOTCAN. In many ways the programs are similar, but in an equal number of ways they are different. For example, HOTCAN is a much smaller program than CMHC-2 and making comparisons is somewhat courageous*. On the other hand, the program is being used as the basis for a number for public sector initiatives in energy conservation. In the jargon of the industry, the following versions of HOTCAN are either available now or will be available in the future:

- R2000/HOTCAN,
- ENERSAVE/HOTCAN, and
- HOMEPLAN/HOTCAN.

However, none of the above versions of HOTCAN contain a financial analysis package, or a Data Management System. It is our view that energy conservation measures in the future will be based more and more on economic considerations. This can be the basis of CMHC-2's role in the future.

New and improved energy conservation products are coming onto the market on a daily basis. John Naisbitt in his book Megatrends suggests

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* Comparing CMHC-2 to HOTCAN can also be deceptive.

that: "hundreds of new energy devices (and energy conservation products) will be commercialized and marketed extensively throughout the decade". Moreover, energy prices are expected to stay at about the present level to the end of the decade, then rise as the oil glut disappears due to an increase in the economic cycle and an increase in energy use in other parts of the world. CMHC-2 can be used by product manufacturers and the general public to compare the costs of energy conservation to fuel costs over the next 10 years.

The interviews with four builders indicated a preference for performance standards and energy labelling over prescriptive standards*. However, the sample size is small and may be influenced by the fact that they are not representative of the average builder. A survey should be conducted of builders in the Canadian Home Builders Association to investigate if a more definitive conclusion can be drawn in this regard.

The weakest part of this study is the estimate of the size of the market in North America. It is mainly confounded by a lack of data on the number of builders involved in low-rise housing across Canada. More definitive statistics may be available, but would require a more thorough search. This investigation should be undertaken in the near future.

It would be an enormous task to develop a Data Management System that would provide accurate costs for 54 cities across Canada. According to the user interviews, this is not required because they want to use their own costs for financial calculations. In lieu of this, CMHC should revise the costs for an unnamed, average city in Canada. These

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* This appears to be consistant with the view of the CHBA TRC (meeting held June 19, 1985).

costs would be used mainly for reference purposes and to assist the user in working his way tnrough the data base when entering his own costs.

11.0 CONCLUSIONS

1. There is a need in the marketplace for a program like CMHC-2. This is based on the fact that about 50% of the participants in the user investigation indicated they were prepared to purchase the program.
2. The user interviews indicated that the participants were mainly interested in operating the program in MODES 1, 2, and 5. The users thought they would run about one-half as many cases in MODE 4 as in MODES 1 and 2. Moreover, they showed the least amount of interest in MODE 3 because they were unyielding about using their own costs.
3. The comparative study indicated that of the 22 computer programs identified, only 4 were seen to be comparable to CMHC-2: CALPAS-3 ($195 U.S.), CIRA ($300 U.S.), F-LOAD ($425 U.S.), and HOTCAN ($55 CDN).
4. The interviews with four builders showed a decided preference for performance standards and energy labelling over prescriptive standards. However, the builders were concerned that this might increase the price of the house (airtightness tests, computer program, labelling).
5. The results of the implementation analysis indicated a fair price for the program in the $200 to $300 range.
6. The size of the market in Canada was estimated to be in the neighbourhood of 1500 to 3700 customers. This is subject to potentially the largest source of error in the analysis.

12.0 RECOMMENDATIONS

Before the program is released, it is recommended that CMHC undertake the following:

1. Overhaul and debug the data base for one, unnamed location in Canada.
2. Simplify the system for determining the construction and heating system codes.
3. Replace the "cryptic descriptors" with precise wording.
4. Provide a complete and detailed manual for the program.
5. Provide HELP routines in the Data Management System to assist the user.

Concurrent with the above work, CMHC should undertake a program to validate both the thermal and financial analysis sections of the CMHC-2 software. Documents should be produced that state the assumptions in the program and describe the methods used to calculate both the space heating requirements and the financial parameters. The theory behind the program and the program validation can be prepared as separate documents.

Developing an energy auditing package for retrofitting existing houses was seen by the participants as being the most important new feature to be incorporated into CMHC-2. This would include:

- recommendations and upgrades for retrofits of existing houses, and
- a provision to include the results of an airtightness test to calculate the natural infiltration rate.

In the immediate future a short list of upgrades should be developed for:

- improving the airtightness of the building by caulking and sealing,

- insulating the ceiling, walls, and basement, and
- installing alternative conventional, or energy-efficient heating appliances.

As with the existing data base, flags should be included that indicate when the building is being made too tight for acceptable indoor air quality and safe combustion in furnaces.

In regard to marketing the program, CMHC should take advantage of public sector initiatives in energy conservation to develop a market for the program. This can best be accomplished by releasing the program to a private company for distribution. A private company, through advertising and promotion, can lobby the decision makers in government about utilizing his product.

The company should also be encouraged to pursue sales of the program in both the United States and Canada. The largest market is in the U.S.; therefore, CMHC should consider the addition of climatic data for American cities as well as incorporating an air conditioning routine into the program.

CMHC-2 appears to be a marketable product based on the user interviews; however, the bulk of the participants showed the greatest amount of interest in MODES 1 and 2. CMHC should consider making a second program available that is considerably reduced in size. This program could be called CMHC-2; the present program under development could be called Super CMHC-2. This would meet a need for software in the home computer market.

CMHC should undertake a marketing study to fill a number of gaps and holes in this study. These include questions related to both the small sample size and the size of the market.

13. REFERENCES

1. "Comparative Evaluation of CMHC-2 Computer Program", Preliminnary Report, G.K. Yuill and Associates, Winnipeg, Manitoba, February, 1984.

2. "Comparative Evaluation of CMHC-2", Draft Final Report, G.K. Yuill and Associates, Winnipeg, Manitoba, April, 1984.

APPENDIX A

Questionnaire

QUESTIONNAIRE FOR CMHC-2

1. Your name: _____
(please print)

2. Name and address of business/organization you represent:

_____

_____

_____

3. Your position in the organization: _____

4. What businesses is your organization in? Who are your customers?

Business	Customers
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____

5. Geographically, what area does your company/organization serve?

_____

_____

_____

6. In your geographical business area, how many other organizations of your type exist:

Area	Number of Organizations
_____	_____
_____	_____
_____	_____

7. You have gone through an orientation in CMHC-2. Do you feel that you understand the various features of the program sufficiently to decide if this could be useful for your business/organization?

YES ☐

NO ☐

If NO, what other information do you need to decide if this could be useful for your business/organization?

_____

_____

_____

8. CMHC-2 is a computer program with the following important capabilities. To what extent would these capabilities be useful to your business? Please indicate both the importance and the frequency of their use if you had this program. Please answer in the terms given below:

A) Importance Scale

5	4	3	2	1
Critical				Not Required

B) Frequency - Number of times the particular capability would be used per year.

Capability	Likely Importance	Projected Frequency of Use
8.1 Calculation of heating load and annual space heating requirements.	_____	_____
8.2 Calculation of investment criteria (payback, NPV, etc.) for different upgrades using:		
(a) your own cost estimates for upgrades.	_____	_____
(b) costs supplied by the program .	_____	_____
8.3 Given a dollar limit for expenditures for upgrading, the program selects the optimum options for upgrading then conducts a financial analysis.	_____	_____

8.4 Within specified tolerances (by the user) for R-values, heating system efficiency, infiltration rates, etc., the program will iteratively fix the above values so that the calculated energy consumption matches the actual consumption (auditing). _____ _____

8.5 Incorporating your own component and fuel costs into the program data files. _____

8.6 Incorporating your own performance parameters (R-value, efficiency) into the programs data files. _____

8.7 Incorporating your own default values for occupancy, shading coefficients, tightness performance, etc. _____

8.8 Others (please specify) _____

_____ _____ _____

9. Does your organization use a computer program in the areas of design or energy analysis?

NO ☐ YES ☐

if YES,

9.1 Name of the program _____

Features of the program used _____

Frequency of use _____

9.2 Please assess your present program below:

Feature _____ Comment _____

Ease of Input _____

_____

Usefulness of Output _____

_____

Appropriateness of Analysis Method _____

_____

Level of Documentation (Manual) _____

_____

Problem Areas _____

_____

Suggested Improvements _____

_____

10. If you were to use CMHC-2, what benefits would accrue to your organization?

Place a check mark (✓) in the appropriate blank:

- increased profits. _____
- improved housing sales. _____
- sound basis for including energy conservation features in a house. _____
- firm basis for designing energy conservation programs and policies. _____
- firm basis for developing performance or prescriptive standards (example HELP, R-2000). _____
- improved research, development and demonstration capabilities. _____
- improved teaching capabilities in regard to the cost and performance of energy conservation technologies. _____
- improved customer relations. _____

11. How much are these benefits worth in terms of dollars? _____

12. If CMHC-2 were available to you, what would be the frequency of its use per year? _____

_____

13. Can you make the decision to acquire CMHC-2 software?

YES ☐

NO ☐

If NO, who can make this decision in your organization? _____

14. Does your organization own or have access to computers? If yes, please give details.

Type(s) of computer(s): _____

_____

15. Please name the job titles of the people in your organization who use computer programs available to you. _____

_____

16. CMHC-2 runs on an IBM-PC micro-computer as well as main-frame computers.

Would you need to acquire a computer in order to be able to use CMHC-2?

YES ☐ NO ☐

17. Which of your needs does CMHC-2 meet? Explain.

_____

_____

_____

18. Which of your needs does CMHC-2 not meet? Explain.

_____

_____

19. If you acquired CMHC-2, how would you prefer to access the program?

- Through local CMHC office _____
- Your own Personal Computer _____
- Your own mini or main-frame computer (time sharing) _____

20. For what applications would you apply CMHC-2?

_____ New construction

_____ Existing construction retrofit

_____ Existing construction audits

_____ Costing

_____ Sales, public relations, and marketing

_____ Custom designs

_____ Regulatory approvals (standards)

_____ Research, development, and demonstration

_____ Other _____
(please specify)

_____ Other _____

_____ Other _____

21. If CMHC-2 was available to you, is there a reason why you would not use it? Please specify.

_____

_____

_____

_____

22. What features in the program do you like?

_____

_____

_____

23. What features do you dislike?

_____

_____

_____

_____

24. What features in CMHC-2 should be improved (fixed) before it is released?

_____

_____

_____

25. What is a fair price for CMHC-2?

$100 _____

$300 _____

$500 _____

$1000 _____

Why? _____

_____

_____

26. What other support is required for CMHC-2? What is a fair price for this support?

Support	(✓)	Fair Price
(a) Hands-on training course?	_____	_____
(b) On-going program updates for construction assemblies, new products, problem solving?	_____	_____
(c) Others (please specify)?	_____	_____

27. Given the fair prices outlined by you for CMHC-2 and its support:

(a) will your company, or agency, purchase CMHC-2?

YES ☐ NO ☐

(b) in your area of work, how many companies, or agencies, in your estimate will purchase CMHC-2? _____

28. How would you rate the importance of the following enhancements to CMHC-2 using the following importance scale?

5 Critical 4 3 2 1 Not Required

_____ The addition of 54 cities to the data base.

_____ Extension to a full costing program for the base house.

_____ Recommendations and upgrades for energy audits or retrofits.

_____ The provision to include the results of an airtightness test to calculate infiltration.

_____ The addition of cooling analysis (air conditioning).

_____ The capability of modelling a poorly insulated house (using codes).

_____ A more complete description of the recommendations for upgrades.

_____ A simpler more direct method of determining the proper code for a construction assembly or heating system.

_____ The inclusion of a drafting package as a part of the Computer Assisted Design package (CAD).

29. Using the above scoring system (question 28), how important are the following features in programs like CMHC-2?

_____ A complete and detailed manual.

_____ Training packages and courses.

_____ Program operating speed.

_____ Ease of user access to data files.

_____ Documentation of the theory upon which the program is based.

_____ Field and theoretical validation of the program.

_____ Features that allow for a comparison with various standards (HELP, R2000, Measures, Northern Residential Standard).

30. General Comments? _____

_____

_____

APPENDIX B

Private Business

APPENDIX B: Private Businesses

General Comments of Users

Builders (2 respondent):

The idea of the system is good, but more work is required before costing can be accurate. Builders will need to input their own costs into the data base and require an easy way to change them. CMHC-2 would probably only be used by a large builder. A small builder would not have the time to spare. It would take 3 or 4 days to learn how to use the program, and the data files would have to be updated on a day-to-day basis. Costs are different between Regina and Saskatoon (160 miles) and do change on a day-to-day basis. There is no doubt that Computer Assisted Design packages for housing will be used by builders in the future.

Real Estate Board (1 respondent):

The program has little or no application in this area. This is because the largest market is for existing housing where there is little application for CMHC-2. Moreover, their people do not have the basic skills to run the program, even if it is user-friendly. Not much use is made of their existing user-friendly program that lists the real estate transactions taking place in the City.

Architectural Firms (1 respondent):

The program has tremendous potential. Designers and architects working in the housing field would make good use of it. They look forward to its completion.

Owner-Builder (1 respondent):

The program is useful, but the frequency that it would be required (of expected use) is very limited.

Manufacturer of Insulated Siding (1 respondent):

CMHC-2 can be used by manufacturers to aid product sales. It should have been out 5 years ago to prevent over-insulating (with respect to cost effectiveness). It appears to be an excellent program. The problem with HOTCAN is that you have to do a lot of calculations before you input the data. Then after this is over the data is lost (no filing system), except for the printout. CMHC-2 allows you to store a base house and work with any feature of interest to you.

1. Businesses and the number of organizations of their type that exist in their geographical area (questions 1 to 6).

Business	Number of Organizations
builders	22
architects	23
real estate board	1
owner-builder	unknown
building product manufacturer	2

2. Usefulness of application options of CMHC-2 (questions 8). Importance scale: 1 (not required) to 5 (critical).

Option	Likely Importance	Annual Frequency of Use
MODE 1 (simple analysis)	3.4	26
MODE 2 (user specifies cost)	3.6	12
MODE 3 (program specifics cost)	2.8	7
MODE 4 (optimum options)	3.4	10
MODE 5 (auditing and retrofit)	3.2	6
Incorporating into data files:		
- own costs	3.4	N/A
- own performance parameters	2.6	N/A
- own default values	2.6	N/A

Overall frequency of use: 10 to 30 times per year (question 12).

All participants felt that they understood the features of the program well enough to decide if it would be useful to their organization (question 7).

3. Assessment of current program being used (question 9):
   - 3 out of 5 users have HOTCAN. Others do not use a program.
   - Features used: energy analysis, heating costs, furnace sizing.
   - Frequency of use: 10 to 15 times per year.
   - Ease of input: fairly simple to use.
   - Usefulness of output: good for comparing savings for different insulation or construction methods.
   - Appropriateness of analysis method: adequate.
   - Level of documentation: adequate.
   - Suggested improvements: facility to save data files, improve the cost of energy calculation.

4. Benefits of CMHC-2 (questions 10 and 11):
   - sound basis for including energy conservation features in a house (5/6).
   - only the manufacturer identify increased profits as a benefit (1/6).
   - improved housing sales (3/6).
   - a dollar figure could only be put on the benefits of CMHC-2 by the manufacturer = $20,000/year.

5. Existing Computational Facilities (questions 14, 15, 16, 19):
   - all users have access to computers. Types include: Wang, IBM-PC, TRS-80, IBM-system 32, HP 3000 series.
   - the existing computers are mainly used by accounting personnel, draftsmen, or real estate sales personnel for listings.

- 3 of 5 expect the program to run on their present machines;
- access is preferred on their own mini or main-frame computers.

6. Needs met by CMHC-2 (question 17):
   - design, analysis, costing, option selection.
   - same as HOTCAN plus costing.
   - energy and cost analysis.
   - priorities and costs for energy saving features in new and existing housing.
   - provide purchasers of new housing with the details of the savings due to energy conservation features.
   - provide a service to purchasers of existing houses on how a house can be upgraded.

7. Needs not met by CMHC-2 (question 18):
   - do not believe the cost data can be kept up to date without more work than it may be worth.
   - choosing the design priority for features besides energy conservation (total cost of construction of one type versus another type, i.e., grade beam versus full basement).
   - accurate design of unique (exotic), custom housing.
   - does not really fit into the selling needs of a real estate person selling existing houses, which is the largest market.

8. Applications of CMHC-2 (question 20):
   - new construction (5/6)
   - existing construction retrofits (6/6).

- existing construction audits (3/6).
- costing (4/6).
- custom designs (4/6).

9. Reasons they would not use CMHC-2 (question 21):
   - 3 of 5 stated there is no reason they would not use it. The others gave the following reasons for not using it:
     - more refinement needed (get the bugs out).
     - accuracy of data base.
     - it would not be used as a selling tool regularly.
     - it would be difficult to tra-n people for the amount of time it would be used.

10. Features liked (question 22):
    - graphic plan evaluation potential.
    - ability to do multiple comparisons, including payback period and results over the term of a mortgage.
    - all features.
    - default, cost benefit, payback period, construction costs.

11. Features disliked (question 23):
    - seems slow.
    - would not impact on housing sales to a large degree.
    - system of coding materials and systems is confusing and often not very specific.
    - the work required to get the results you need may take too long.

12. Features to be Improved (question 24):

    - bugs must be ironed out.
    - more accurate data base on an on-going basis for each region.
    - coding method for materials and systems.
    - user friendliness.

13. Fair Price for CMHC-2 (question 25):

    - $100 (2/6): price for HOTCAN $55, wide usage, $1000 more realistic.
    - $300 (3/6): compared to other software on the market (other than HOTCAN).
    - $500 (1/6): no reason given.

14. Other support required (question 26):

	Fair Price ($)
(a) hands-on training course (4/6).	100 to 500
(b) on-going updates (4/6).	25

15. Will you purchase CMHC-2? (question 27):

	Yes	No	Unknown	Number of Purchasers in your Area of Work
builder	1		1	20
architects		1		unknown
real estate		1		unknown
owner-builder		1		none
manufacturer	1			20

16. Future Technical Development (question 28): Scoring system 5 (critical) to 1 (not required).

    2.4 The addition of 54 cities to the data base.

    3.2 Extension to a full costing program for the base house.

    3.4 Recommendations and upgrades for energy audits or retrofits.

3.4 The provision to include the results of an airtightness test to calculate infiltration.

2.6 The addition of cooling analysis (air conditioning).

2.2 The capability of modelling a poorly insulated house (using codes).

3.2 A more complete description of the recommendations for upgrades.

4.2 A simpler more direct method of determining the proper code for a construction assembly or heating system.

3.0 The inclusion of a drafting package as a part of the Computer Assisted Design package (CAD).

17. Future Development of Overall Package (question 29): Scoring system 5 (critical) to 1 (not required).

4.8 A complete and detailed manual.

4.4 Training packages and courses.

3.5 Program operating speed.

4.3 Ease of user access to data files.

3.5 Documentation of the theory upon which the program is based.

3.5 Field and theoretical validation of the program.

4.0 Features that allow for a comparison with various standards (HELP, R2000, Measures, Northern Residential Standard).

APPENDIX C

Government Agencies

APPENDIX C: Government Agencies

General Comments of Users

Utility (1 respondent):

They are definitely interested; however, the main use would be to produce fact sheets for their customers.

Others (4 respondents):

They all liked the format for the data screens, although their first impression was that the program is a bit complicated. They would also like: more complete documentation, HELP routines, and a better method for determining codes. In regards to the codes, they suggested an approach where the required geometry and materials are input and the program picks the correct code. Complete instructions on how to update the date files was also recommended. Moreover, the manual should contain flow charts that describe what is happening in the program.

They also commented that a user of CMHC-2 would have to have complete trust in the authors of the program. The integrity of the program must be demonstrated.

1. Number of Organizations of their type that exist in their geographical area (questions 1 to 6).

Organization	Saskatoon	Saskatchewan	Canada
Energy, Mines and Resources Canada	1	1	12
Provincial Agriculture Department	N/A	1	10
Provincial Housing Authority	N/A	1	10
Utility (natural gas and electric)	N/A	1	10

2. Usefulness of application options of CMHC-2 (question 8): Importance scale: 1 (not required) to 5 (critical).

Option	Likely Importance	Annual Frequency of Use
MODE 1 (simple analysis)	2.8	30
MODE 2 (user specifies cost)	2.6	30
MODE 3 (program specifies cost)	2.2	27
MODE 4 (optimum options)	2.8	27
MODE 5 (auditing and retrofit)	3.2	47
Incorporating into data files:		
- own costs	4.2	N/A
- own performance parameters	3.6	N/A
- own default values	3.2	N/A
Other: retrofit components	5.0	3

Overall annual frequency of use: 160 cases per year (question 12).

All participants felt that they understood the various features of the program sufficiently to decide if it could be useful for their organization (question 7).

3. Assessment of current program being used (question 9):

- 4 of 5 use the HOTCAN program, 1 does not use anything.
- Features used: performance of new housing, annual heat loss, heating system design, payback for retrofit, new house designs.
- Frequency of use: 200 to 300 cases per year (EMR); however, 2 of 5 just received HOTCAN and are only starting to use it.
- Ease of input: capable of simple or detailed input, takes about 5 minutes for a complete run, easy to use.

- Usefulness of output: excellent for new housing contractors, compares output with SEEH energy budget only, subject to input error and output interpretation.
- Appropriateness of analysis method: appropriate for new housing, difficult to reconcile fuel bills with existing, reasonably accurate.
- Level of documentation: good, seems to have holes in it, adequate.
- Problem Areas: no models for slab and crawlspace, saving runs, making changes to house file.
- Suggested Improvements: should run through change menu step by step.

4. Benefits of CMHC-2 (questions 10 and 11)
   - sound basis for including energy conservation features in a house (4/5).
   - firm basis for designing energy conservation programs and policies (3/5).
   - improved customer relations (2/5).
   - improved teaching capabilities (2/5).
   - improved R&D capabilities (2/5).
   - a dollar figure could not be put on the benefits of CMHC-2 by this group.

5. Existing Computational Facilities (questions 14, 15, 16, 19).
   - all have access to computers. Types include: North Star Advantage, IBM-PC, IBM-XT, mini's and main frames.
   - the computers are used by: Technical Advisors, Engineers, R&D People, Systems People, and Customer Advisors.

- 2 of 5 have an IBM-PC/XT.
- all would prefer access on their own Personal Computer.

6. Needs met by CMHC-2 (question 17):
   - costs for various construction components.
   - probably more than needed.
   - ability to balance known fuel bills (audits).
   - comparison of different building systems.
   - cost/benefit of upgrading energy efficiency in housing.
   - retrofit and energy use advice to customers.

7. Needs not met by CMHC-2 (question 18):
   - simplicity and speed.
   - too early to tell.
   - quick calculations.
   - retrofit capabilities.

8. Applications of CMHC-2 (question 20):
   - new construction (3/5).
   - existing construction retrofits (5/5).
   - existing construction audits (4/5).
   - costing (3/5).
   - public relations (2/5).
   - research and development (2/5).

9. Reasons they would not use CMHC-2 (question 21):
   - 2 of 5 said there is no reason why they would not use it. The others gave the following reasons for not using it:

- time required for input.
- home owners can't be trained to fill out data sheets.
- program may be more precise than required.
- extremely lengthy input/output routines.

10. Features liked (question 22):
    - level of detail and ability to supply cost for options.
    - reconciliation of existing parameters with fuel bills.
    - thoroughness.
    - can analyze retrofits.
    - wide variety of program features.
    - life-cycle costing and financial analysis.
11. Features not liked (question 23):
    - errors in data base.
    - problems maintaining data base.
    - large number of codes.
    - too much information (dislike too strong a term).
    - no provision for secondary heating systems.
    - reference system for codes is cumbersome.
    - data input sheets expensive (HOTCAN on one page).
    - extra degree of accuracy/versatility may not be necessary compared to extra time required.
12. Features to be improved (question 24):
    - cosmetics.
    - easy access to data files to make changes.
    - as per 11.

13. Fair price for CMHC-2 (question 25):

- $100 (3/5): R2000 HOTCAN, $55, development paid for by general public.
- $300 (2/5): cost of most software
- $500 (0/5):

14. Other support required (question 26):

	Fair Price ($)
(a) hands-on training course (4/5).	50 to 100
(b) on-going updates (5/5).	20 to 100

15. Will you purchase CMHC-2? (question 27):

	Yes	No	Number of Purchasers in your Area
EMR	1	1*	12
Provincial Agricultural Department	1		unknown
Provincial Housing Authority	1		1
Utility	1		1

*two individuals from EMR, yes is senior.

16. Future Technical Development (question 28): Scoring system 5 (critical) to 1 (not required).

4.2 The addition of 54 cities to the data base.

3.0 Extension to a full costing program for the base house.

4.2 Recommendations and upgrades for energy audits or retrofits.

3.2 The provision to include the results of an airtightness test to calculate infiltration.

1.8 The addition of cooling analysis (air conditioning).

4.4 The capability of modelling a poorly insulated house (using codes).

2.8 A more complete description of the recommendations for upgrades.

3.2 A simpler more direct method of determining the proper code for a construction assembly or heating system.

2.0 The inclusion of a drafting package as a part of the Computer Assisted Design package (CAD).

17. Future Overall Development Package (question 29): Scoring system 5 (critical) to 1 (not required).

4.8 A complete and detailed manual.

3.2 Training packages and courses.

3.4 Program operating speed.

4.4 Ease of user access to data files.

2.6 Documentation of the theory upon which the program is based.

4.4 Field and theoretical validation of the program.

2.8 Features that allow for a comparison with various standards (HELP, R2000, Measures, Northern Residential Standard).

2. Usefulness of application options of CMHC-2 (questions 8). Importance scale: 1 (not required) to 5 (critical).

Option	Likely Importance	Annual Frequency of Use
MODE 1 (sample analysis)	4.8	50
MODE 2 (user specifies cost)	4.5	40
MODE 3 (program specifies cost)	4.1	35
MODE 4 (optimum options)	3.3	25
MODE 5 (auditing and retrofit)	3.0	8
Incorporating into data files:		
- own costs	4.8	N/A
- own performance parameters	2.8	N/A
- own default parameters	3.2	N/A

Overall frequency of use: 0 to 50 times per year (question 12).

Two of four participants felt they did not understand the features of the program well enough to decide if it would be useful to their organization (question 7). The following reasons were given:

- verification of data,
- costs,
- availability, and
- decision whether accuracy of analysis, warranted time of input.

3. Assessment of current program(s) being used (question 9):

- all participants use the HOTCAN program.
- Features used: Total design heat loss/optimization.
- Frequency of use: just received, 100 cases per year, daily, 5000 to 10,000 cases per year.

- Ease of input: fair to excellent.
- Usefulness of output: very good to excellent.
- Appropriateness of analysis method: acceptable to very good.
- Level of documentation: poor to good.
- Problem areas: over predictions.
- Suggested improvements: more detailed input.

4. Benefits of CMHC-2 (questions 10 and 11)

- improved teaching capabilities in regard to the cost and performance of energy conservation technologies (4/4).
- sound basis for including energy conservation features in a house (3/4).
- firm basis for designing energy conservation programs and policies (2/4).

5. Existing Computational Facilities (questions 14, 15, 16, 19).

- all users have access to computers. Types include: IBM PC/XT, North Star Advantage, and mainframes.
- the computers are used by mechanical engineers, associates, technical staff, and clerical support staff.
- 2 of 4 participants have an IBM-PC or XT. All participants prefer to access the program on their own Personal Computer.

6. Needs met by CMHC-2 (question 17):

- more accurate and detailed component optimizations.
- basic energy analysis and component breakdown.
- decisions on where to spend extra money on energy retrofits and new house construction.
- cost benefit analysis.
- establishes incremental cost of component upgrades and priorize options.

APPENDIX D

Researchers and Educators

APPENDIX D: Researchers and Educators

General Comments of Users

- I like it. Would be interested in details on the infiltration model.
- Very good program. Should be accurate and very useful to builders.
- I think it will be a great help in our situation (Technical Institute), and can see many opportunities for training students in house construction. It can be used as a teaching aid to tell them what they should do and why, for both new construction and retrofit. The program has many possibilities.
- I am impressed with the obvious potential and power of this program. But its usefulness will depend on the reliability of the data base.

1. Businesses and the number of organizations of their type that exist in their geographical area (questions 1 to 6).

Organization	Saskatoon	Saskatchewan	Canada
Private Research Consultant	1	unknown	unknown
Technical Institute	1	3	unknown
Federal Laboratory	1	1	1
Provincial Laboratory	1	1	10
University	1	2	10

2. Usefulness of application options of CMHC-2 (questions 8). Importance scale: 5 (critical) to 1 (not required).

Option	Likely Importance	Annual Frequency of Use
MODE 1 (simple analysis)	3.3	17
MODE 2 (user specifies cost)	2.0	14
MODE 3 (program specifies cost)	1.8	10
MODE 4 (optimum options)	1.8	10
MODE 5 (auditing and retrofit)	2.4	14
Incorporating into data files:		
- own costs	1.8	N/A
- own performance parameters	2.2	N/A
- own default values	2.1	N/A

Overall annual frequency of use: 0 to 20 (difficult to estimate for most users) (question 12).

Two of five participants stated that they did not understand the features of the program sufficiently to decide if CMHC-2 was useful to their organizations. The following reasons were given:

- would need to test CMHC-2 and compare with results obtained by other methods.
- more information required on actual methods for calculating heating loads (i.e. how are the following accounted for: internal gains, solar gains, night setback, etc) (question 7).

3. Assessment of current program(s) being used (question 9):

- 4 of 5 participants use the HOTCAN program, 1 also used DOE-2 and ENERPASS, 1 does not use a program.

- Features used: space heating analysis (HOTCAN), hour by hour heating and cooling load (DOE-2, ENERPASS).

	HOTCAN	ENERPASS
Ease of input	excellent	very easy
Usefulness of output	very good	heating and cooling load, temperature variations
Appropriateness of analysis method	very good	main frame, may soon be available on IBM-PC
Level of documentation	adequate	well documented
Problem areas	over predictions	no optimization routine or costing of components, takes 5 minutes of CPU
Suggested improvements	more detailed input	-

4. Benefits of CMHC-2 (questions 10 and 11):

   - improved research, development and demonstration capabilities (4/5).
   - improved teaching capabilities (3/5).
   - firm basis for designing energy conservation features in a house (2/5).

5. Existing computational facilities (question 14, 15, 16, 19):

   - all have access to computers. Types include: IBM-PC, Apple II, HP 1000, DEC VAX 11/780, HP 85, Commodore 64, etc.
   - computers are used by: Professionals, Technicians, students.
   - 3 of 5 would have to obtain an IBM-PC.
   - all would prefer access at their own Personnal Computer.

6. Needs met by CMHC-2 (question 17):
   - optimize the design of energy-efficient housing and determine the performance and cost for research purposes,
   - heat loss and financial analysis.
   - ways which would help us build better buildings and keep costs down (instruction of students).
   - comparison to other models, demonstration, display.

7. Needs not met by CMHC-2 (question 18):
   - more development in the retrofit area.
   - must understand the inner workings of the program.
   - the needs in item 6 are not met because of the obvious defects in the data base and a distrust of the computer program.
   - the program has built-in assumptions and algorithms that have not been spelled out.
   - flags should be incorporated for building code requirements (i.e. solid core door to attached garage plus automatic closer).
   - program does not appear to be simple to use.
   - insufficient on-screen instruction for selecting codes, HELP routines.

8. Applications of CMHC-2 (question 20):
   - research, development, and demonstration (5/5).
   - new construction (3/5).
   - existing construction retrofits and audits (3/5).

9. Reasons they would not use CMHC-2 (question 21):
   - 2 of 5 said there is no reason why they would not use it. Another did not comment.

The reasons for not using CMHC-2 were:

- maintaining and editing the data base.
- use of codes and cryptic descriptions is tricky and somewhat difficult.
- does not calculate overheating or cooling loads.
- method for handling natural ventilation is suspect.
- would not use it until recommendations are shown to agree with reality.
- reliability of recommendations not demonstrated.
- some recommendations lack practicality.
- lack of confidence in data files.

10. Features liked (question 22):

- user friendly, well-designed screens, ease of branching to different parts of the program, page up/down.
- upgrade ranking (financial) is fantastic.
- menu driven, financial aspects are nice.
- variable-base degree-day method should be fairly accurate.
- flexibility and range of application.
- attempts to address an area not covered by other programs.
- appears to be a lot of good sound technology behind it.

11. Features not liked (question 23):

- may be time consuming to maintain accurate data base.
- can I have faith in the integrity of the calculations it performs?
- how many people would have the time and ability to use such a complicated program?

- ideal would be to eliminate the need for constant reference to manuals or printed tables.
- cannot specify allowable temperature swings.
- does not calculate cooling load.
- optimization does not include south window area (for passive solar gain) or thermal mass for storage.
- dislike having to go through tables in a manual to obtain input information (codes).
- slowness. Would be better on a main frame.
- a "mouse" may be better (to move the cursor).
- data base is unreliable; not confident it will ever be de-bugged.
- HELP routines are needed.
- lack of summary printout after a run.
- the selection of the city should be incorporated into the Local Climate Screen.

12. Features to be improved (question 24):

- better explanation of cryptic descriptions in manual.
- addition of flow charts to show what the various parts of the program do.
- addition of bar and pie charts to printout.
- data base interactions (bugs).
- credibility can be achieved by careful and documented validation of all component models for the Canadian climate.
- verification of the overall model in the field.
- update and improve data base.

- listing appropriate building code requirements, or changes, along with the upgrades in MODE 4.
- the program seems to treat a house like a system of non-interacting components. In many cases this is impractical. For example, a 2 or 4 mil air/vapour barrier may be recommended for the ceiling, while 4 or 6 mil may be recommended for the walls. Another example is awning windows for the basement and sliders for the walls.
- there must be a thorough overhaul and broadening of the data base.
- tests must be conducted to verify the accuracy of every piece of information in the data base.
- a document must be produced that gives the assumptions in the program, and describes the algorithms used for both thermal and financial analysis.

13. Fair price for CMHC-2 (question 25):
    - $100 to $500 range. average $300.
    - if the price is modest, the use will be greater and the quality of housing improved.

14. Other support required (question 26):

	Fair Price
(a) hands-on training course (3/5)	unknown to $50
(b) on-going updates (5/5)	unknown

15. Will you purchase CMHC-2? (question 27).

	Yes	No	Unknown	Number of Purchasers in your Area
Private Research Consultant			1	unknown
Technical Institute	1			unknown
Federal Laboratory		1		unknown
Provincial Laboratory	1			unknown
University			1	unknown

- program seems to be geared more towards builders than researchers.
- number of sales to the research community may be small.

16. Future Technical Development (question 28): Scoring system 5 (critical) to 1 (not critical).

4.6 The addition of 54 cities to the data base.

2.6 Extension to a full costing program for the base house.

3.8 Recommendations and upgrades for energy audits or retrofits.

4.6 The provision to include the results of an airtightness test to calculate infiltration.

2.8 The addition of cooling analysis (air conditioning).

3.0 The capability of modelling a poorly insulated house (using codes.

3.8 A more complete description of the recommendations for upgrades.

3.7 A simpler more direct method of determining the proper code for a construction assembly or heating system.

2.3 The inclusion of a drafting package as a part of the Computer Assisted Design package (CAD).

17. Future Overall Development Package (question 29): Scoring system 5 (critical) to 1 (not required).

5.0 A complete and detailed manual.

2.5 Training packages and courses.

3.9 Program operating speed.

4.4 Ease of user access to data files.

5.0 Documentation of the theory upon which the program is based.

4.5 Field and theoretical validation of the program.

3.7 Features that allow for a comparison with various standards (HELP, R2000, Measures, Northern Residential Standard).

APPENDIX E

R2000 Coordinators

APPENDIX E: R2000 Coordinators

General Comments of Users

Builder:

CMHC-2 appears to be a well designed program which offers some advantages over other pgorams such as HOTCAN. The component coding system seems tedious; however, it may be quicker once a person becomes more familiar with it.

EMR:

Please regard my comments as preliminary. Many of the difficulties envisioned may be overcome with experience using the system. CMHC-2 appears to be needlessly complex for the analysis that is output.

1. Businesses and number of organizations of their type in their geographical area (questions 1 to 6).

Business	Number of Organizations in geographical business area	Canada
Builder	27	N/A
consulting engineer	5	75
house designer	4	N/A
EMR	N/A	N/A

7. Needs not met by CMHC-2 (question 18):
   - no response from participants.
8. Applications of CMHC-2 (question 20):
   - new construction (4/4).
   - existing construction retrofits (4/4).
   - existing construction audits (2/4).
   - costume designs (3/4).
   - research development and demonstration (4/4).
9. Reasons they would not use CMHC-2 (question 21):
   - complexity and time required relative to the task.
   - require a strong reason before switching from HOTCAN.
   - accuracy of energy analysis would have to be significant better than HOTCAN.
   - comparison with BLAST analysis (verification) would likely be required.
   - depending on the use, the different added inputs may not be justified.
10. Features liked (question 22):
   - more detailed than HOTCAN.
   - costing capabilities.
   - the air leakage routine is good: if it is accurate.
   - the financial and system upgrade ranking is beneficial in that it can help to justify to clients the upgrade choices.
   - materials data bank on RSI values.
   - emphasis on energy and financial integration and analysis.

11. Features disliked (question 23):

- looks a bit tedious to use.
- time and complexity, specifically the coding and library.
- looking up coding for wall assemblies, etc.
- cryptic descriptors.
- lack of detail regarding algorithms used for heat loss calculations and financial analysis.
- cost file on data base impossible to keep current and regionally accurate.
- constant need to reference component description code and menu.

12. Features to be improved (question 24):

- simplify input.
- automatic selection of wall and window assemblies.
- ease of use.
- if menu driven, more user friendly.

13. Fair Price for CMHC-2 (question 25):

- $100 (2/4): to compete with more user friendly and low cost software.
- $500 (1/4).
- no response (1/4).

14. Other support required (question 25):

	Fair Price ($)
(a) hands-on training course (3/4).	0 to 100
(b) on-going updates (3/4).	0 to 50

15. Will you purchase the program? (question 27):

	Yes	No	Unknown	Number of Purchases in your Area
builder	1			15
consulting engineer			1	200 to 500*
house designer			1	6 to 12
EMR			1	no response

*if it can replace HOTCAN

16. Future Technical Development (question 28): Scoring system 5 (critical to 1 (not required).

4.3 The addition of 54 cities to the data base.

2.8 Extension to a full costing program.

3.5 Recommendations and upgrades for energy audits and retrofits.

4.8 The provision to include the results of an airtightness test to calculate infiltration.

3.0 The addition of cooling analysis (our conditioning).

3.8 The capability of modelling a poorly insulated house.

3.5 A more complete description of the recommendations for upgrades.

4.8 A simpler more direct method of determining the proper code for a construction assembly or heating system.

3.5 The inclusion of a drafting package as a part of the Computer Assisted Design package (CAD).

17. Future Development of Overall Package (question 29): Scoring system 5 (critical) to 1 (not required).

5.0	A complete and detailed manual.
4.5	Training packages and courses.
3.3	Program operating speed.
3.8	Ease of user access to data files.
4.3	Documentation of the theory upon which the program is based.
5.0	Field and theoretical validation of the program.
3.3	Features that allow for a comparison with various standards (HELP, R2000, Measured, Northern Residential Standard).